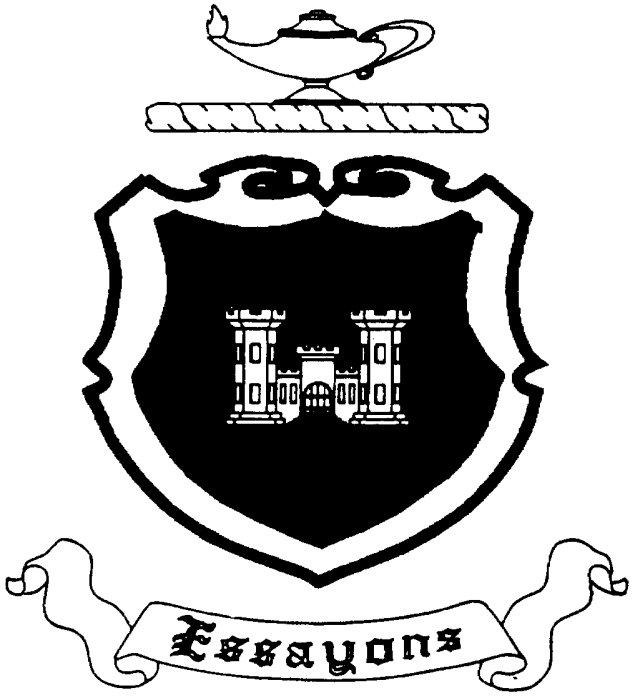
SUBCOURSE
EN5157

EDITION
A

US ARMY ENGINEER CENTER AND SCHOOL

MASONRY



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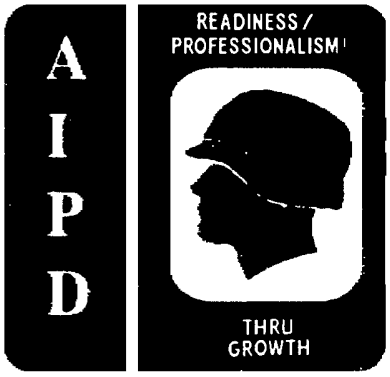

MASONRY

Subcourse EN5157

EDITION A

United States (US) Army Engineer School
Fort Leonard Wood, Missouri 65473

6 Credit Hours

Edition Date: December 1996

SUBCOURSE OVERVIEW

This subcourse is designed to teach soldiers the basic information that is needed to construct concrete-block and brick walls. The information will assist you in the construction of different types of walls. As a carpenter or mason, you must be able to design and construct concrete-block ad brick structures that are safe and structurally sound. Work must be accomplish in a manner consistent with environmental laws and regulations.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine that was current at the time it was prepared. In your own work situation, always refer to the latest official publications.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will identify procedures used to construct a concrete-block and brick wall.

CONDITION: You will be given this subcourse and an Army Correspondence Course Program (ACCP) examination response sheet.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

TABLE OF CONTENTS

LESSON 1

SELECT MORTAR MATERIALS AND MIX MORTAR

Critical Task: 051-236-1146

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn the procedures for selecting mortar materials and mixing the mortar for a concrete-block or brick wall.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will select the mortar and identify the steps when mixing mortar for a concrete-block or brick wall.

CONDITION: You will use the materials contained in this lesson.

STANDARD: You will correctly answer the practice exercise questions at the end of this lesson.

REFERENCES: The materials contained in this lesson were derived from FM 5-426, FM 5-742, STP 5-51B12-SM-TG, and materials approved for instruction by the US Army Engineer School.

INTRODUCTION

As a carpenter or mason, you will be expected to select correct mortar materials for a brick or block wall. You must be able to design and construct structures that are safe and structurally sound. A major part of that responsibility is to choose the best materials available to accomplish this task.

PART A - MATERIALS

To construct a concrete-block wall, you will need concrete blocks and the basic ingredients for mortar (cement, lime, sand, and water). Other ingredients that speed up or slow down the curing time of mortar are called admixtures.

1-1. Blocks. When storing concrete blocks, use good storage techniques. Never allow the blocks to get wet before you lay them. Excess moisture in concrete blocks will cause shrinkage when drying. Stockpile the blocks on a raised platform to prevent the absorption of ground moisture. At the end of the workday, cover the stockpile of blocks with a waterproof tarpaulin to protect them from the rain.

1-2. Mortar (cement). Specifications for the types of portland cement are covered by the American Society for Testing and Materials (ASTM) and include types with the following characteristics:

- Type I is a general purpose cement and the most commonly used. It is generally used in mortar.
- Types II is used in concrete.
- Type III is a high early-strength cement. Although Type III takes as long as Type I to set, it will achieve its full strength much sooner. It is sometimes specified for cold weather because it requires shorter protection time. Type III is generally used in mortar.
- Types IV and V are used in concrete.

1-3. Lime. Cement provides the strength of mortar while lime acts as a plasticizing agent providing smoothness and workability. Lime also increases the water-holding capacity of mortar without it, the mixture would be stiff and unworkable.

1-4. Sand. Sand used in mortar must be clean and free of organic materials; individual particles should be well-graded as to size. In a good mortar, all sand particles are completely coated with cemetitious material (paste). This permits the separate ingredients, or aggregates (sand and stone or gravel), to roll over each other and produce a plastic, workable mortar.

1-5. Water. Water used in mortar should be clean and free of acids, alkalies, salts, and organic matter. As a general rule, drinking water is suitable for making mortar.

1-6. Admixtures. Besides the four basic ingredients (Figure 1-1), any other materials added to the mortar are called admixtures. The most common admixtures are accelerants and retardants.

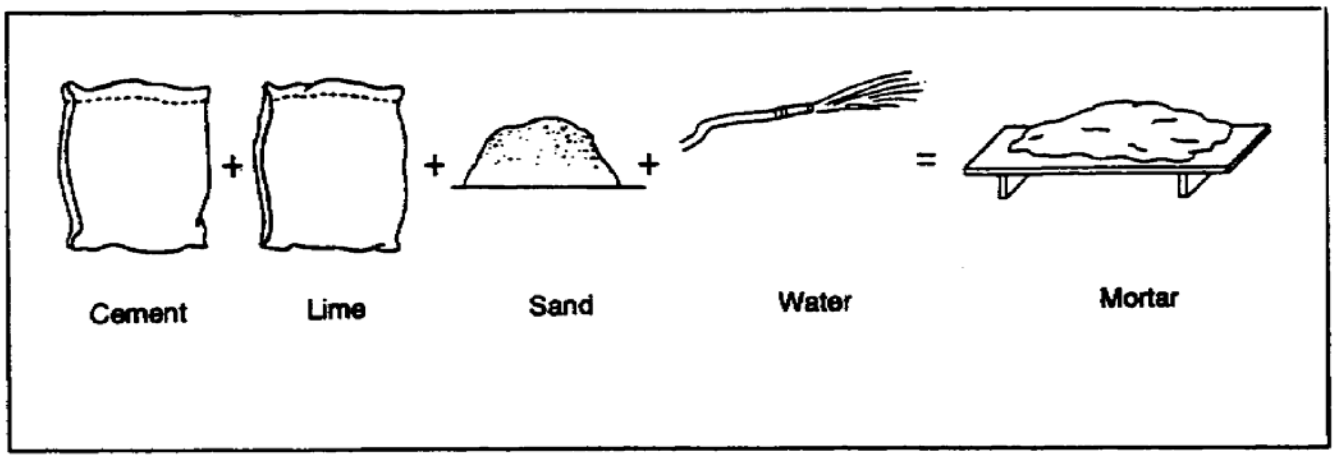

Figure 1-1. Ingredients of mortar

1-7. Accelerants. An accelerant is an agent that speeds up the curing time of mortar. One such accelerant is calcium chloride. This is sometimes used when working conditions are very cold (40 degrees Fahrenheit or below) and there is a danger of the mortar freezing before it is completely set. However, since calcium chloride corrodes metal, its use is discouraged by most building codes. Instead, heating devices and Type III cement are recommended.

1-8. Retardants. Retardants are admixtures that slow down the curing time of mortar. These may be specified when conditions are very hot and dry, causing the mortar to set too rapidly and never attain its strength. However, most building codes discourage the use of retardants when other means of retarding, such insulation, may be used.

PART B - MORTAR BOND

The overlapping arrangement of the concrete block or bricks in the wall is called a mortar bond. A bond is achieved when the mortar hardens and knits them together. The strength of the mortar bond is affected by the-

- Type and quality of the cementing material
- Workability or plasticity of the mortar.
- Surface texture of the mortar-bedding area.
- Water retention of the mortar.
- Quality of the workmanship.

1-9. Sand. Clean, sharp sand produces excellent mortar. Too much sand causes the mortar to segregate. You can make mortar that is easily workable by properly grading the sand and thoroughly mixing the other aggregates.

1-10. Water Retentivity. Loss of moisture due to poor water retention results in the rapid loss of plasticity and may seriously reduce the strength of the bond. To ensure the strength of the bond-

- Keep concrete blocks dry until they are built into the wall.
- Do not wet concrete blocks/bricks to control suction before application of mortar.
- Use lime where weather conditions are hot and dry. Lime slows down the evaporation of moisture in mortar, since it retains water.

PART C - MORTAR FORMULAS

Formulas allow for variations of proportions within the types of mortar. The volume of sand should never exceed three times the combined volume of cement and lime. If you use too much sand, the mortar will be weaker and less workable. Most building codes and specifications call for ASTM mortar types M, S, N, or O (Table 1-1).

Table 1-1. Proportions of mortar types

Materials (parts by volume)				
Type	Portland Cement	Hydrated Lime		Sand
		Minimum	Maximum	
M	1	--	1/4	Not less than 2 1/4 and not more than 3 times the sum of the total volume of cement and lime
S	1	1/4	1/2	
N	1	1/2	1 1/4	
O	1	1 1/4	2	

1-11. Type M. Type M mortar is composed of 1 part cement, 1/4 part lime, and 3 3/4 parts sand. This mortar has a high cement-to-lime proportion that makes for a very strong mortar. This type of mortar is suitable for general use. It is recommended specifically for structures that are below grade and in contact with the earth, such as foundation, retaining walls, and walkways.

1-12. Type N. Type N mortar is composed of 1 part cement, 1 1/4 parts lime, and 6 3/4 parts sand. Type N has excellent workability because of its high lime content. It does not have the strength of Type M or Type S mortar. Type N-

- May be used in bearing walls that are above grade if stress is not too great.
- Is widely used in veneers.
- Is used in partitions and some exterior walls where climatic conditions are negligible.

1-13. Type O. Type O mortar is composed of 1 part cement, 2 parts lime, and 9 parts sand. It is extremely plastic and workable (notice the lime content) but has relatively low strength.

Type O should not be used if it will be subjected to freezing and thawing in the presence

of excessive moisture. Many building codes do not allow Type O mortar for construction. However, some local building codes allow Type O to be used for load-bearing walls of solid blocks when the compressive stresses do not exceed 100 pounds per square inch. Before using this type mortar, check local building codes.

1-14. Type S. Type S mortar is composed of 1 part cement, 1/2 part lime, and 4 1/2 parts sand. It is a very good general-purpose mortar used in above-grade exteriors that are exposed to severe weathering. Type S is also used in interiors and all load-bearing structures unless only Type M is specified. Type M and S are usually interchangeable.

PART D - MIXING THE MORTAR

Mortar is usually mixed on the job site in portable, mechanical mixers. However, on some small jobs, you can mix mortar by hand.

1-15. Mortar Packaging. The proportions for mortar types are based on volume measurements, and mortar ingredients are packaged by volume. Portland cement is packaged and delivered in 94-pound bags containing 1 cubic foot. Hydrated lime is packaged in 50-pound bags that each contain approximately 1 cubic ft. Sand is delivered by the cubic foot or the cubic yard. A 1:1:6 mortar mix would call for one bag of cement, one bag of lime, and 6 cubic feet of sand. This mixture will equal 6 cubic feet of mortar.

1-16. Machine Mixing. Use the following steps when mixing by machine:

Step 1. Add a small amount of water to the drum. This will prevent the mixture from caking on the machine paddles.

Step 2. Add one-third of the sand.

Step 3. Add all of the lime and the cement.

Step 4. Start the machine and mix for approximately one minute before adding water.

Step 5. Add the remaining sand and water to obtain the desired consistency.

Step 6. Continue mixing for at least three or more minutes after all ingredients are in the machine.

1-17. Hand Mixing. A mortar box is used to mix mortar by hand. It is approximately 5 by 10 feet and can be constructed with 2-inch material (Figure 1-2). The box should be as watertight as possible. Use the following steps when mixing by hand:

Step 1. Place half of sand in the mortar box.

Step 2. Spread the specified amount of lime and cement over the sand.

Step 3. Add the remaining half of the sand. This sandwich operation permits a more thorough mixing with less effort. Turn the mixture twice with a hoe, and then pull it to the end of the box.

Step 4. Add the water and cut the dry mixture back into it. Continue adding water to obtain the desired consistency.

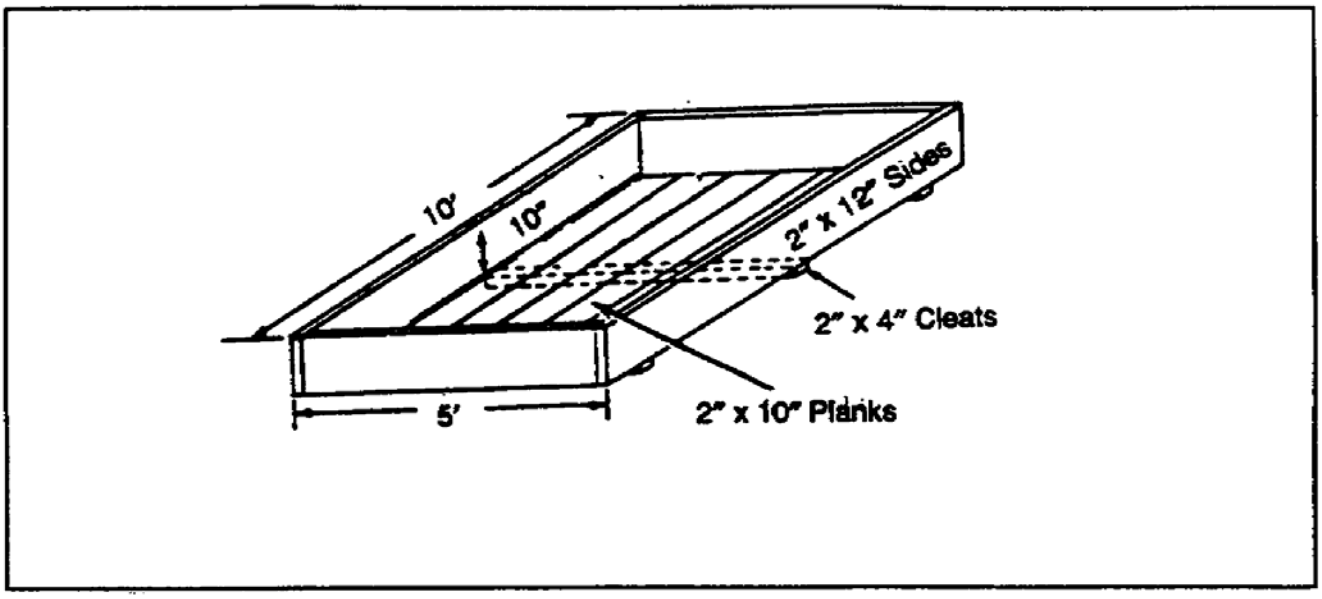

Figure 1-2. Mortar box

1-18. Retempering. If the mortar has become stiff on the mortarboard because of the evaporation of water, you must add water and retemper the mortar to restore its plasticity. Remember the following:

Mortar should be used within 2 1/2 hours after original mixing when the temperature is 80 degrees Fahrenheit or higher.

Mortar should be used within 3 1/2 hours when the temperature is below 80 degrees Fahrenheit.

1-19. Discarding. It is sometimes difficult to determine if the mortar should be remixed and used. If in doubt, discard the mortar. Ensure you comply with all environmental laws and regulations when discarding waste. Never use mortar after it has been dropped on the ground or contaminated in any way.

LESSON 1

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer to each item. When you complete the exercise, check your answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson that contains the portion involved.

1. Which types of portland cement are generally used in mortar?

   A. I and IV
   B. II and I
   C. II and I
   D. IV and V

2. Which ingredient acts as a plasticizing agent in mortar?

   A. Water
   B. Calcium chloride
   C. Cement
   D. Lime

3. Which aggregate component is used in mortar?

   A. Sand
   B. Clay
   C. Lime
   D. Silt

4. What will be the effect on a block wall if there is poor water retention when mixing the mortar?

A. The mortar will take longer to set.
B. The mortar bond will become weaker.
C. The mortar bond will become stronger.
D. The mortar joints will be easier to tool.

5. In mortar, what is the maximum amount of sand, that you can add to the combined volume of cement and line?

A. One times the cement and lime
B. Two times the cement and lime
C. Three times the cement and lime
D. Four times the cement and lime

6. Which mortar is recommended for structures that are below grade and in contact with the earth?

A. S
B. M
C. N
D. O

7. Why is it necessary to add calcium chloride to a mortar mix?

   A. To prevent freeze/thaw hydration
   B. To speed up the curing process
   C. To slow down the curing process
   D. To prevent the evaporation of moisture from the mortar

8. When is it necessary to retemper mortar?

   A. When the mortar has been mixed for one or more hours
   B. When the mortar stiffens
   C. When the mortar falls off the trowel
   D. When the mortar becomes contaminated.

9. When is it necessary to use a mortar box?

   A. When mortar is mixed by hand
   B. When the mortar is too wet to mix
   C. When large amounts of mortar are being used
   D. When fewer than 100 concrete blocks are required

LESSON 1

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		Correct Answer and Feedback	
1.	B.	I and III	(page 1-2, para 1-2)
2.	D.	Lime Cement provides the strength….	(page 1-2, para 1-3)
3.	A.	Sand This permits the separate….	(page 1-2, para 1-4)
4.	B.	The mortar will become weaker.	(page 1-4, para 1-10)
5.	C.	Three times the cement and lime The volume of sand should ….	(page 1-5, part C Introduction)
6.	B.	M It is recommended specifically ….	(page 1-5, para 1-11)
7.	B.	To speed up the curing process An accelerant is an agent ….	(page 1-3, para 1-7)
8.	B.	When the mortar stiffens If the mortar has become ….	(page 1-7, para 1-18)
9.	A.	When mortar is mixed by hand A mortar box is used ….	(page 1-6, para 1-16)

LESSON 2

CONSTRUCT A CONCRETE-BLOCK WALL

Critical Task 051-236-1146

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn how to construct a concrete-block wall.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will learn how to construct a concrete-block wall.

CONDITION: You will be given the materials contained in this lesson.

STANDARD: You will correctly answer the practice exercise questions at the end of this lesson.

REFERENCES: The materials contained in this lesson were derived from FM 5-426, FM 5-742, STP 5-51B12-SM-TG, and materials approved for instruction by the US Army Engineer School.

INTRODUCTION

As a carpenter or mason, you will be expected to construct a concrete-block wall. A carpenter or mason must be able to design and construct structures that are safe and structurally sound. A major part of that responsibility is to chose the best method of construction available to accomplish this task.

PART A - FOOTINGS

Footings are the enlarged areas under the foundation of walls or columns. They distribute the weight of the wall or column over a larger area and prevent it from settling.

2-1. Materials. Footings are normally concrete, although brickwork footings are satisfactory. All footings must be below the frost line to prevent heaving and settlement of the foundation. Column footings for wooden buildings are constructed in the same way as wall footings.

2-2. Sizes. The required footing width and thickness for walls of considerable height or for walls that carry heavy loads should be determined by a qualified engineer. However, for the usual one-story building with an 8-inch wall, a footing 16 inches wide and 8 inches thick should be enough.

PART B - CONCRETE BLOCKS

Buildings are constructed with various sizes and kinds of concrete blocks that can be hollow or solid. The different types of blocks are made with heavyweight or lightweight materials and are normally referred to as such.

2-3. Actual and Nominal Sizes. Concrete blocks come in specific sizes. The 3/8-inch mortar joint has been adopted as the standard-size joint for joining blocks. The actual dimensions of the block are fractional; when combined with a 3/8-inch mortar joint, the dimensions will come out even in inches or nominal sizes. Therefore, a 15 5/8-inch stretcher block with a 3/8-inch mortar joint equals 16 inches. The same explanation holds true for heights and widths.

2-4. Typical Sizes and Shapes. Blocks come in both heavyweight and lightweight materials with full- and half-length sizes. The three-core block can also be obtained as two-core blocks. Figure 2-1, pages 2-3 and 2-4, illustrates some of the typical sizes and shapes of concrete blocks.

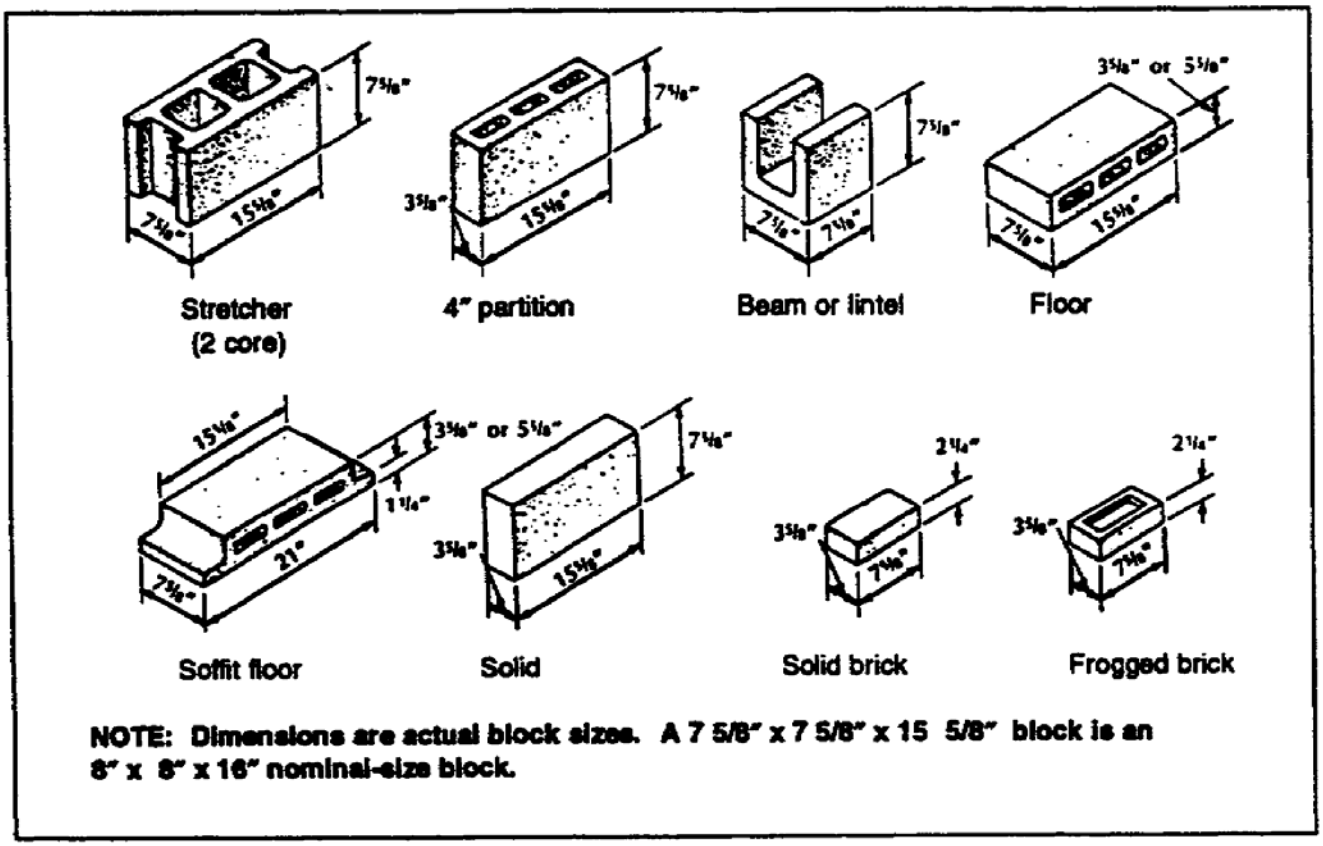

Figure 2-1. Types of concrete blocks

2-5. Types. Concrete blocks come in several different types.

a. Stretcher. A stretcher block is the most commonly used block in construction. It is laid with its length parallel to the face of the wall.

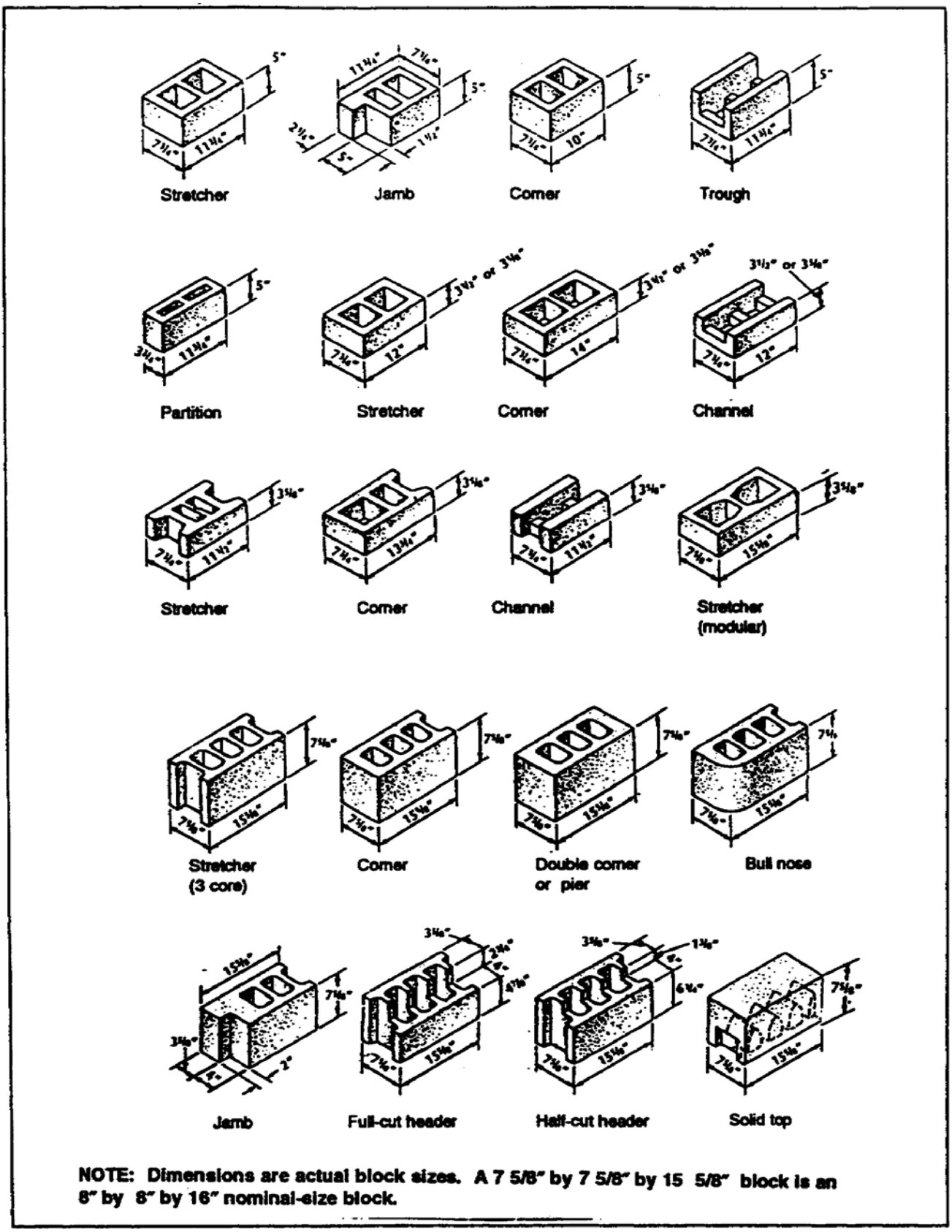

Figure 2-1. Types of concrete blocks (continued)

b. Corner. A corner block is used for corners at simple window and door openings.

c. Double Corner or Pier. A double-corner or pier block is used for constructing piers pilasters or for any other purpose where both ends of the block would be visible.

d. Bull Nose. A bull-nose block serves the same purpose as a corner block, but it is used where round corners are desired.

e. Jamb. A wood-sash jamb block is used with a stretcher and a corner block around elaborate window openings. The recess in the block allows room for the various casing members, as in a double-hung window.

2-6. Most Common Block. The most common concrete block is the hollow, load-bearing stretcher block, which is 8 by 8 by 16 inches nominal size, but 7 5/8 by 7 5/8 by 15 5/8 inches actual size. The heavyweight load-bearing stretcher block weighs from 40 to 50 pounds.

Note: In Figure 2-2, the cores taper toward the top of the block, providing a wider face shell. Always lay this block with the wider face up to allow for a greater area on which to lay a bed of mortar.

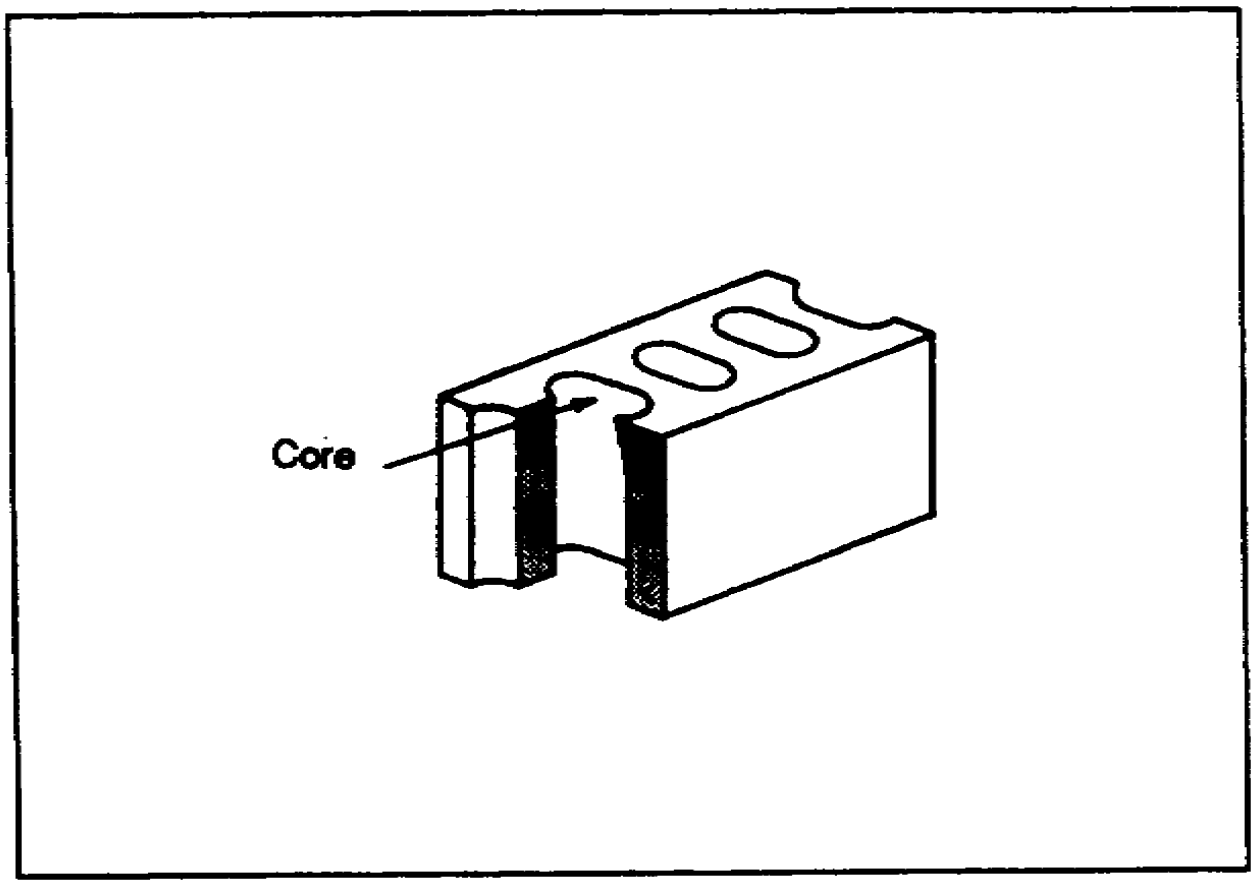

Figure 2-2. Hollow load-bearing stretcher block

PART C - PLANNING THE CONCRETE-BLOCK WALLS

You should lay out concrete-block walls to make maximum use of full- and half-length blocks, since this minimizes cutting and fitting blocks on the job.

2-7. Economical Construction. The most economical concrete-block walls are made of standard stretcher and corner blocks (Figure 2-3).

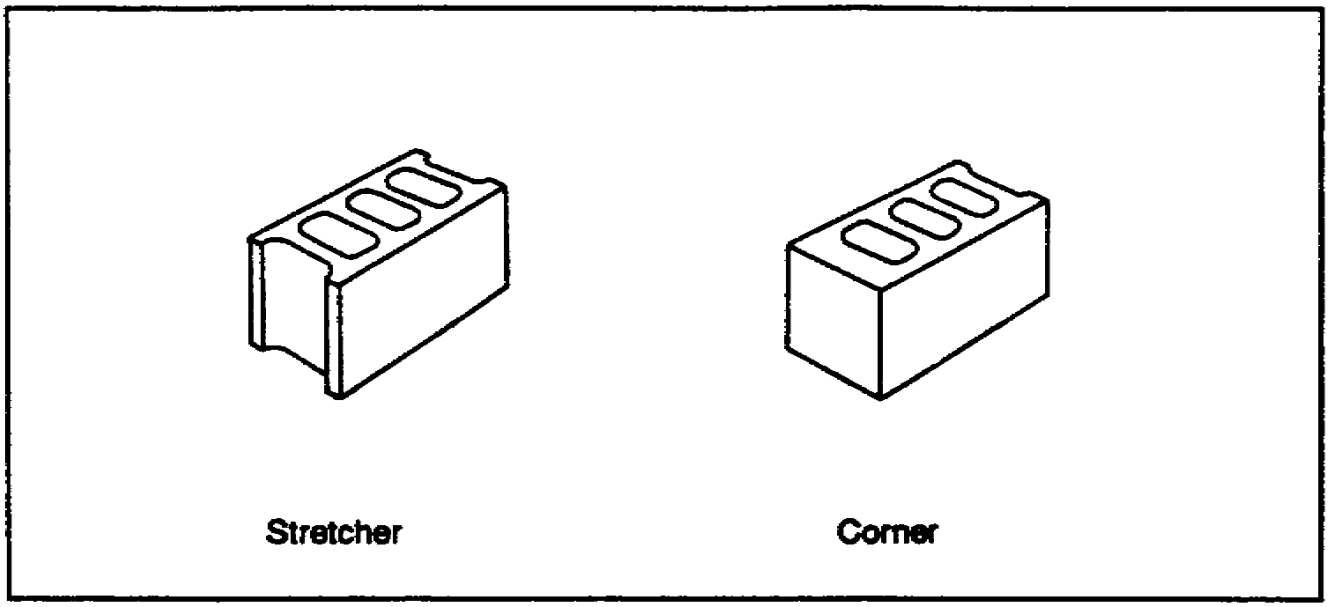

Figure 2-3. Standard blocks

To estimate how many full- and half-size blocks are required, plan the length and height of the wall, the width and height of the openings, and the wall area between doors, windows and corners (Figure 2-4).

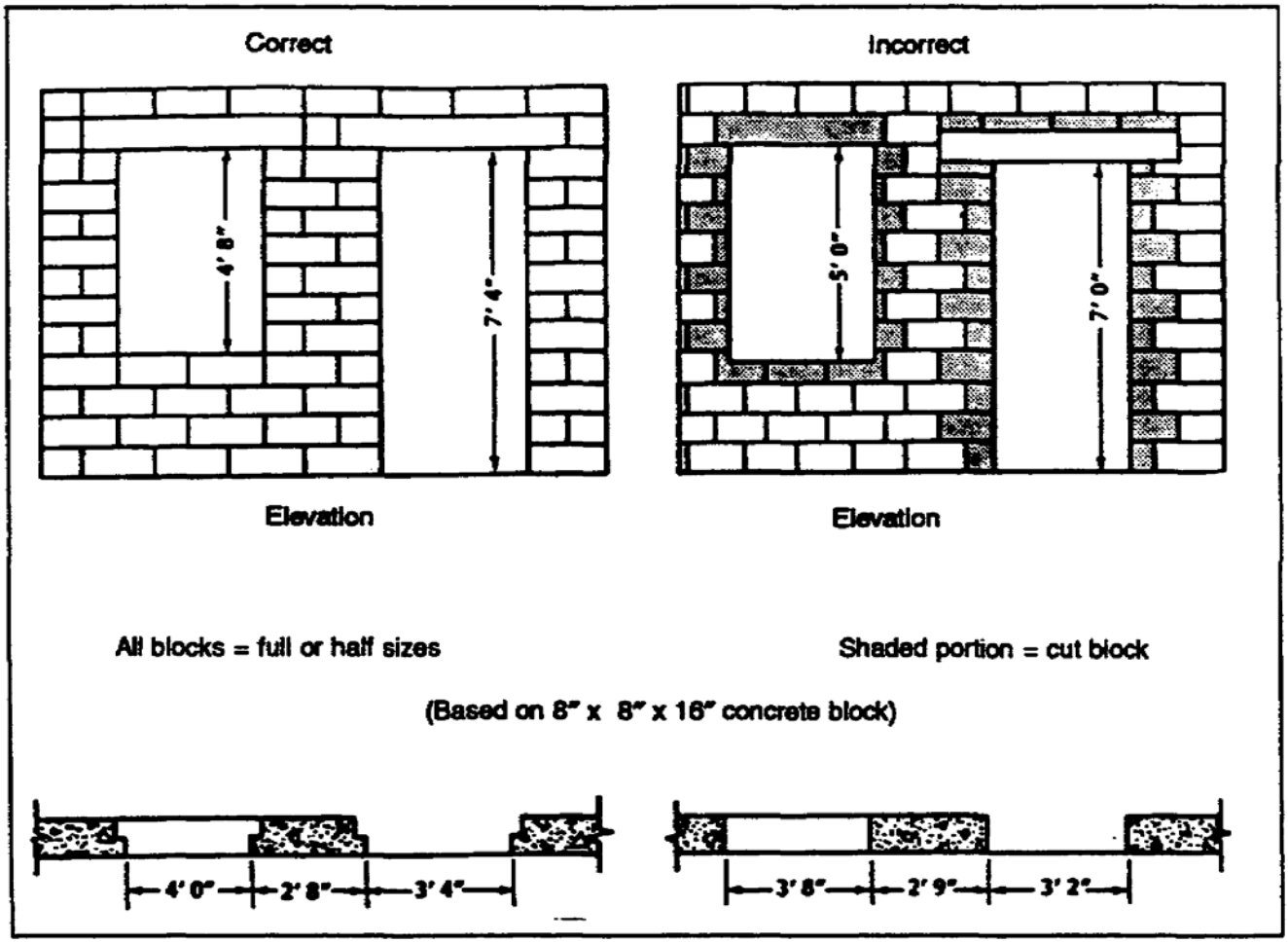

Figure 2-4. Planning concrete-wall openings

2-8. Nominal Length and Height. All horizontal dimensions should be in multiples of nominal full-length blocks. Both horizontal and vertical dimensions should be in multiples of 8 inches. Table 2-1, page 2-8, lists the nominal height of concrete-block walls by stretchers. Table 2-2, page 2-9, lists the nominal length of concrete-block walls by course.

Table 2-1. Nominal height of concrete-block walls

Number of Courses	Blocks 7 5/8" High and Bed Joints 3/8" Thick	Blocks 3 5/8" High and Bed Joints 3/8" Thick
1	8″	4″
2	1′ 4″	8″
3	2′ 0″	1′ 0″
4	2′ 8″	1′ 4″
5	3′ 4″	1′ 8″
6	4′ 0″	2′ 0″
7	4′ 8″	2′ 4″
8	5′ 4″	2′ 8″
9	6′ 0″	3′ 0″
10	6′ 8″	3′ 4″
15	10′ 0″	5′ 0″
20	13′ 4″	6′ 8″
25	16′ 8″	8′ 4″
30	20′ 0″	10′ 0″
35	23′ 4″	11′ 8″
40	26′ 8″	13′ 4″
45	30′ 0″	15′ 0″
50	33′ 4″	16′ 8″

Concrete blocks that are 3 5/8″ by 7 5/8″ are laid with 3/8″ mortar joints. Height is measured from center to center of mortar joints.

Table 2-2. Nominal length of concrete-block walls

Number of Stretchers	Blocks 15 5/8" Long and Half Blocks 7 5/8" Long with Head Joints 3/8" Thick	Blocks 11 5/8" Long and Half Blocks 5 5/8" Long with Head Joints 3/8" Thick
1	1' 4"	1' 0"
1 ½	2' 0"	1' 6"
2	2' 8"	2' 0"
2 ½	3' 4"	2' 6"
3	4' 0"	3' 0"
3 ½	4' 8"	3' 6"
4	5' 4"	4' 0"
4 ½	6' 0"	4' 6"
5	6' 8"	5' 0"
5 ½	7' 4"	5' 6"
6	8' 0"	6' 0"
6 ½	8' 8"	6' 6"
7	9' 4"	7' 0"
7 ½	10' 0"	7' 6"
8	10' 8"	8' 0"
8 ½	11' 4"	8' 6"
9	12' 0"	9' 0"
9 ½	12' 8"	9' 6"
10	13' 4"	10' 0"
10 ½	14' 0"	10' 6"
11	14' 8"	11' 0"
11 ½	15' 4"	11' 6"
12	16' 0"	12' 0"
12 ½	16' 8"	12' 6"
13	17' 4"	13' 0"
13 ½	18' 0"	13' 6"
14	18' 8"	14' 0"
14 ½	19' 4"	14' 6"
15	20' 0"	15' 0"
20	26' 8"	20' 0"

Actual wall length is measured from the outside edge to the outside edge of blocks and equals the nominal length minus 3/8" (one mortar joint).

PART D - FIRST COURSE OF CONCRETE BLOCKS

Before mixing mortar and laying blocks, you should follow these steps:

- Locate the corners of the wall.
- Use a chalk line to mark the footing for aligning the first course of blocks.
- Check the wall layout by placing the blocks along the wall without mortar. Remember to leave a 3/8-inch gap between each block for the mortar joint (Figure 2-5). This will tell you if any cutting is necessary.

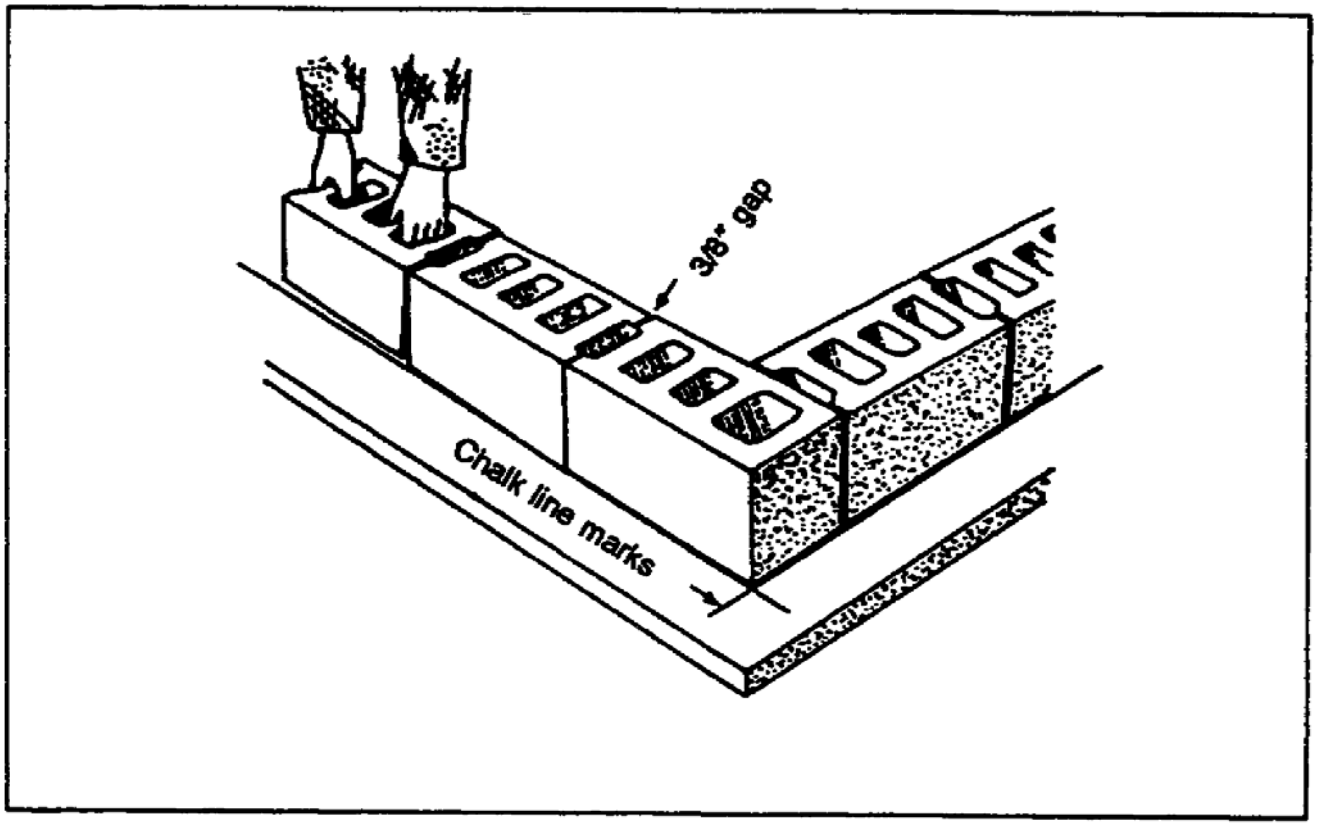

Figure 2-5. Laying out block without mortar

2-9. Spreading the Mortar Bed. Spread a full bed of mortar, and furrow it with a trowel. This will ensure that plenty of mortar is on the bottom of the blocks for the first course (Figure 2-6).

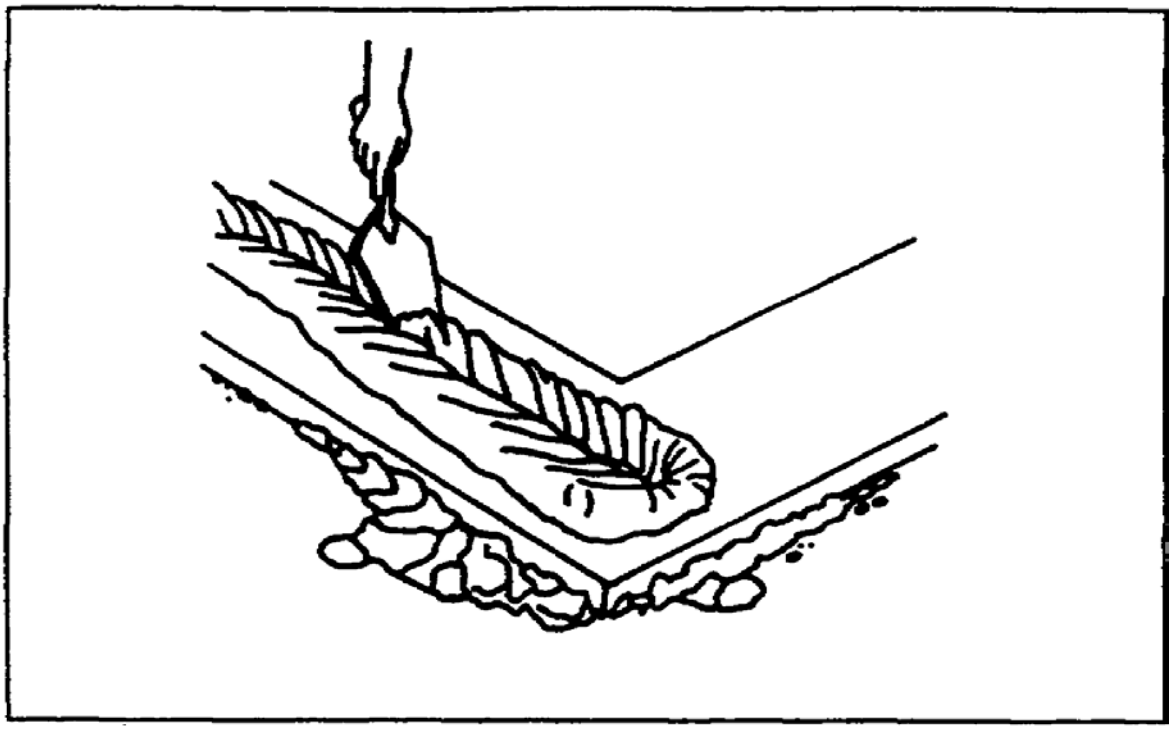

Figure 2-6. Spreading and furrowing the mortar bed

Lay the corner block first and carefully position it. Be sure to lay all blocks with the thicker side of the face shell up to provide a larger mortar bedding area (Figure 2-7).

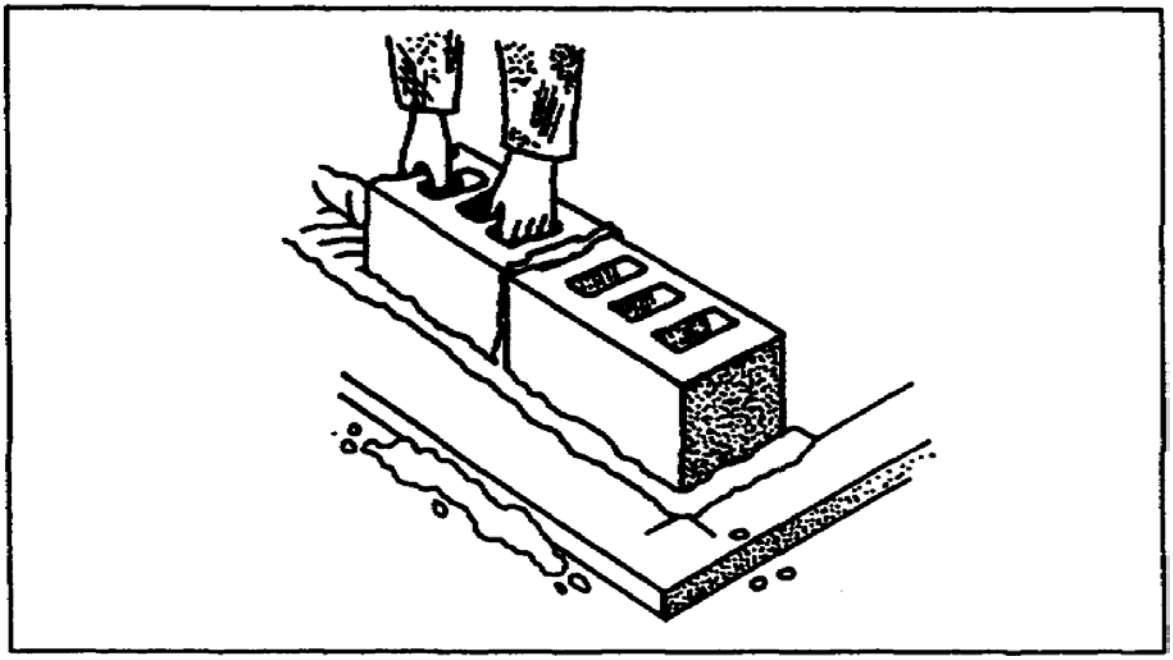

Figure 2-7. Positioning the corner block

2-10. Making Vertical Joints. Apply mortar to the ends of the blocks for vertical joints. You can save time by placing several blocks on the ends and applying mortar to the vertical faces in one operation (Figure 2-8). Then place each block over its final position and push downward into the mortar bed and against the previously laid block to obtain a well-filled vertical joint (Figure 2-9).

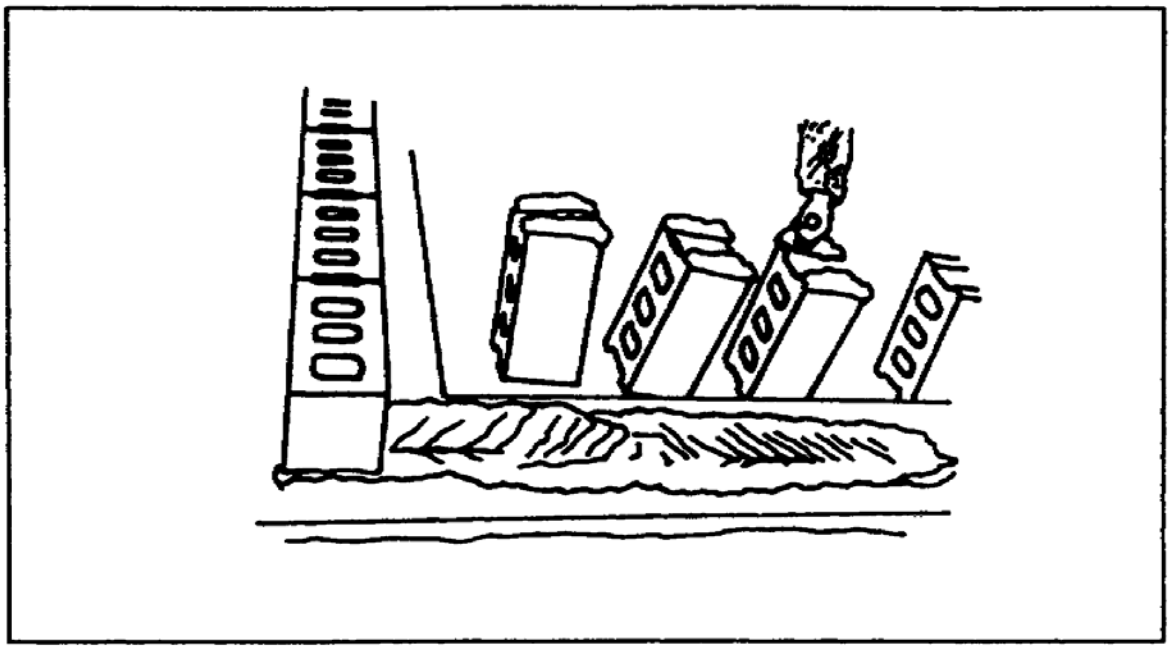

Figure 2-8. Applying mortar for vertical joints

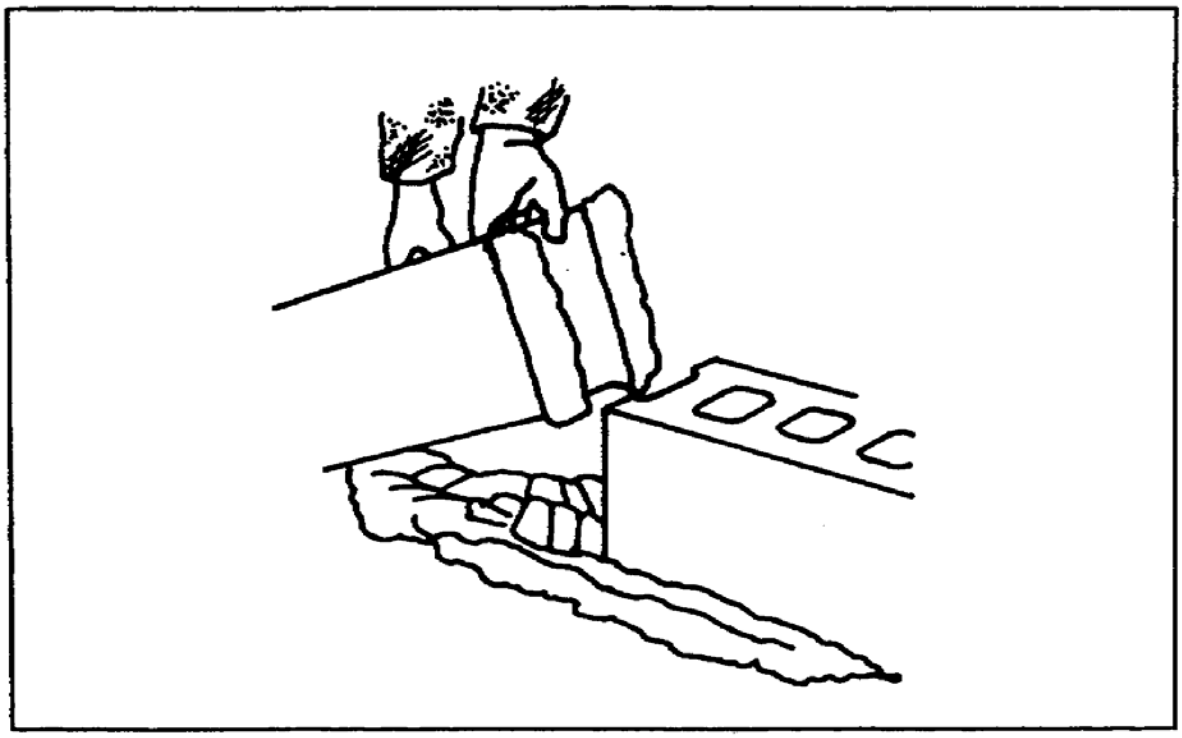

Figure 2-9. Positioning the block

2-11. Aligning, Leveling, and Plumbing. Lay the first course of blocks with great care to ensure that they are properly aligned, leveled, and plumbed. This will make the next course of blocks and the wall itself straight and true. After you have laid three or four blocks, use the mason's level as a straightedge to ensure correct alignment of the blocks. Check the first course of blocks carefully with the level, bringing them to the proper grade. Plumb the blocks by tapping them with the trowel handle (Figure 2-10).

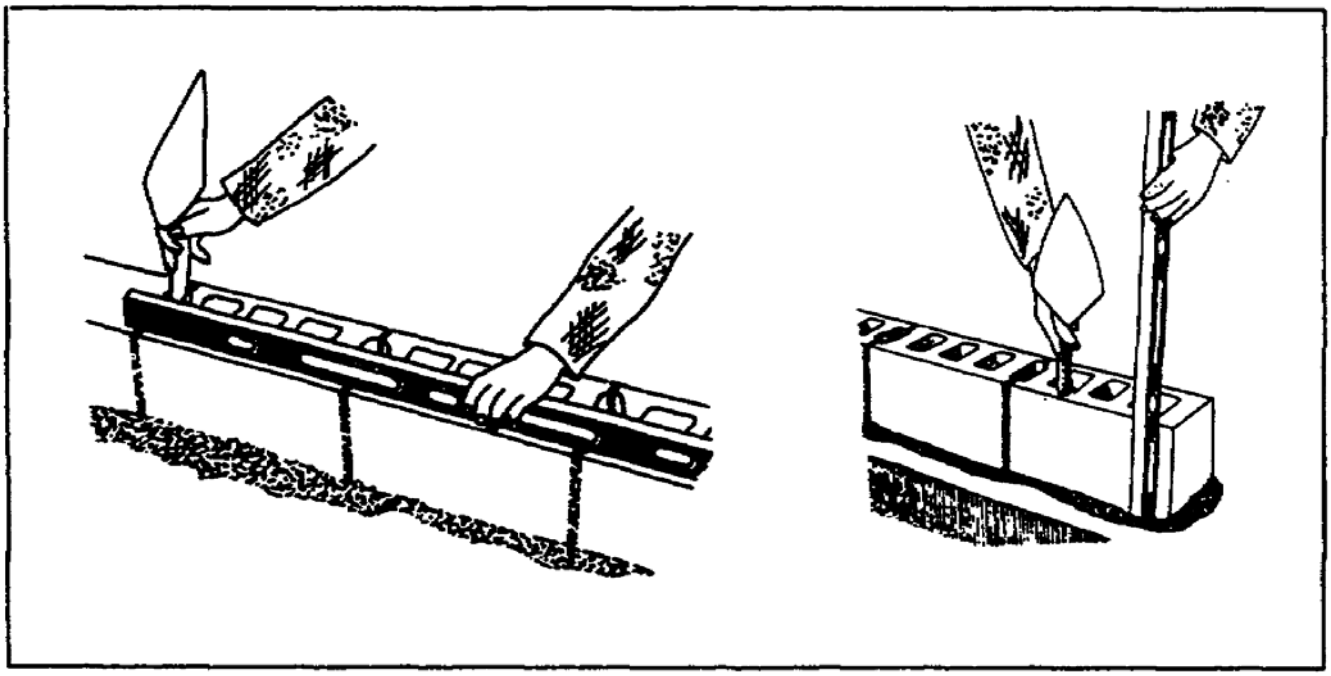

Figure 2-10. Leveling and plumbing the blocks

PART E - CONTROL JOINTS

Control joints are continuous vertical joints that are built into concrete-blocks walls to control cracking from unusual stress. They are usually spaced at 20- to 25-foot intervals in long walls and extend to the top course. A wall shorter than 20 feet does not normally require a control joint.

2-12. Using Full- and Half-length Blocks. Use full- and half-length blocks to form a continuous vertical joint which will permit slight wall movement without cracking. You should lay control joints up in mortar just like any other joint (Figure 2-11).

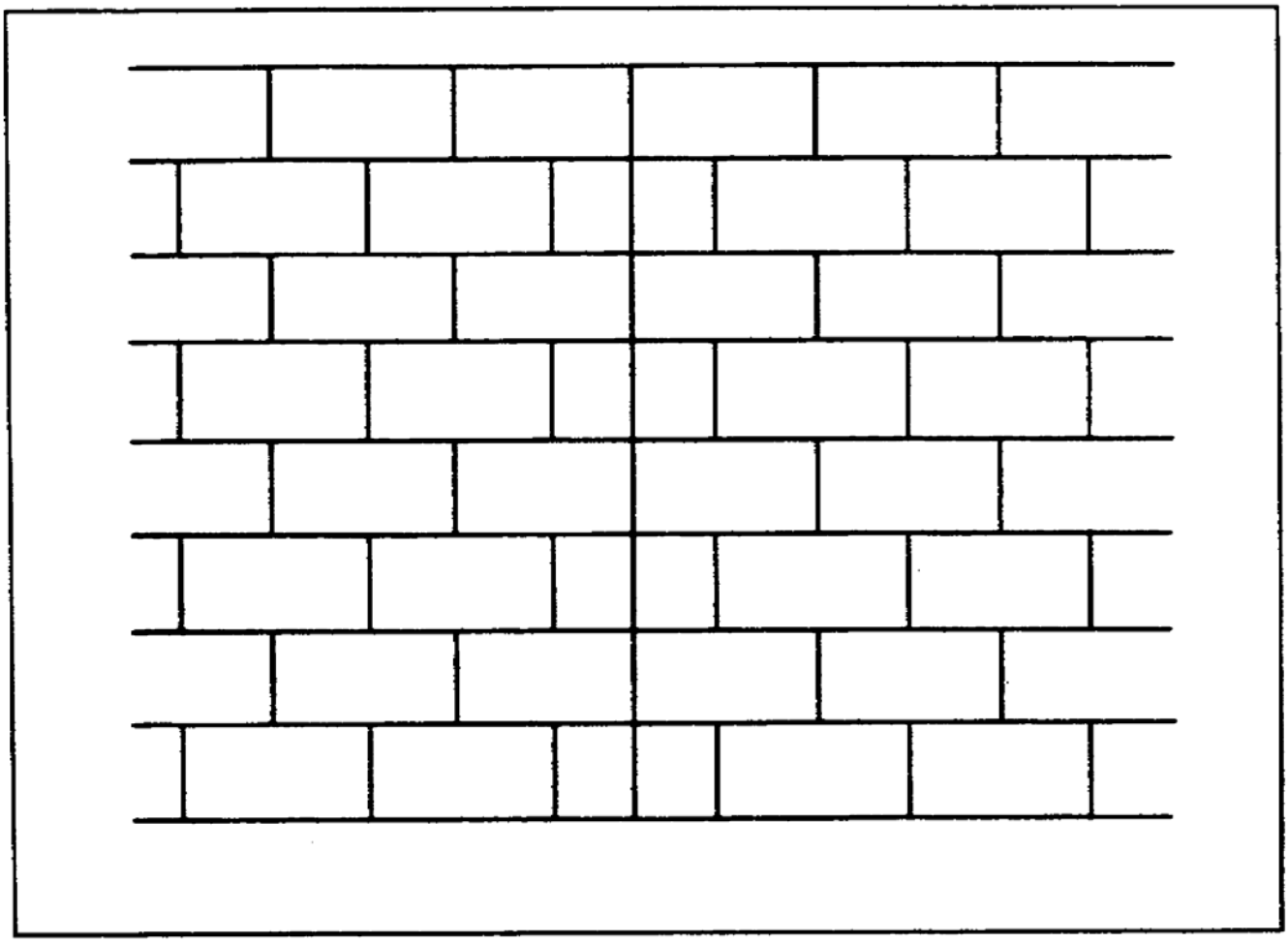

Figure 2-11. A control joint using full- and half-length blocks

2-13. Using Paper and Felt. You can make another type of control joint by inserting building paper or roofing felt in the end core of the block and extending it the full length of the control joint. Cut the paper or felt to convenient lengths. Make sure it is wide enough to extend across the joint to prevent the mortar from bonding on one side of the joint (Figure 2-12).

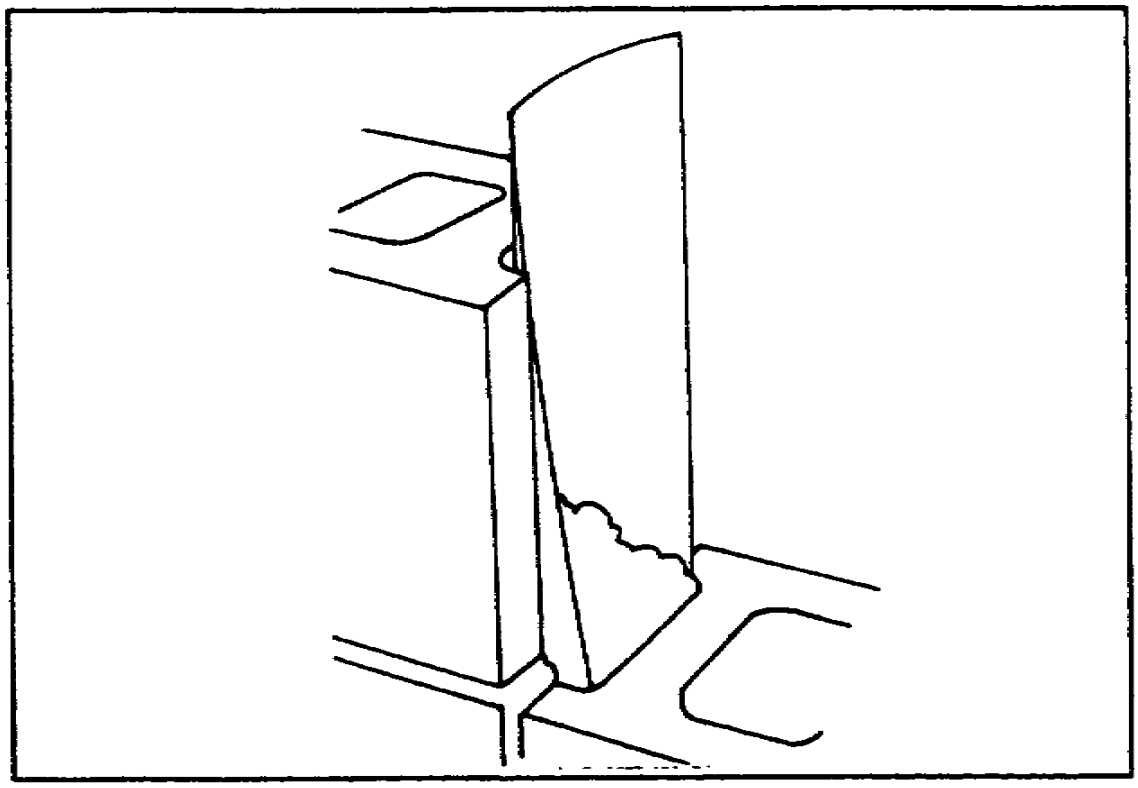

Figure 2-12. Control joints using paper or felt

2-14. Caulking. If the control joints are exposed to the weather or to view, you should caulk them. When the mortar in the control joint is stiff, rake it out to a depth of 3/4 inch to provide a recess for the caulking materials (Figure 2-13, page 2-16). Use a thin, flat caulking trowel to force the caulking compound into the joint.

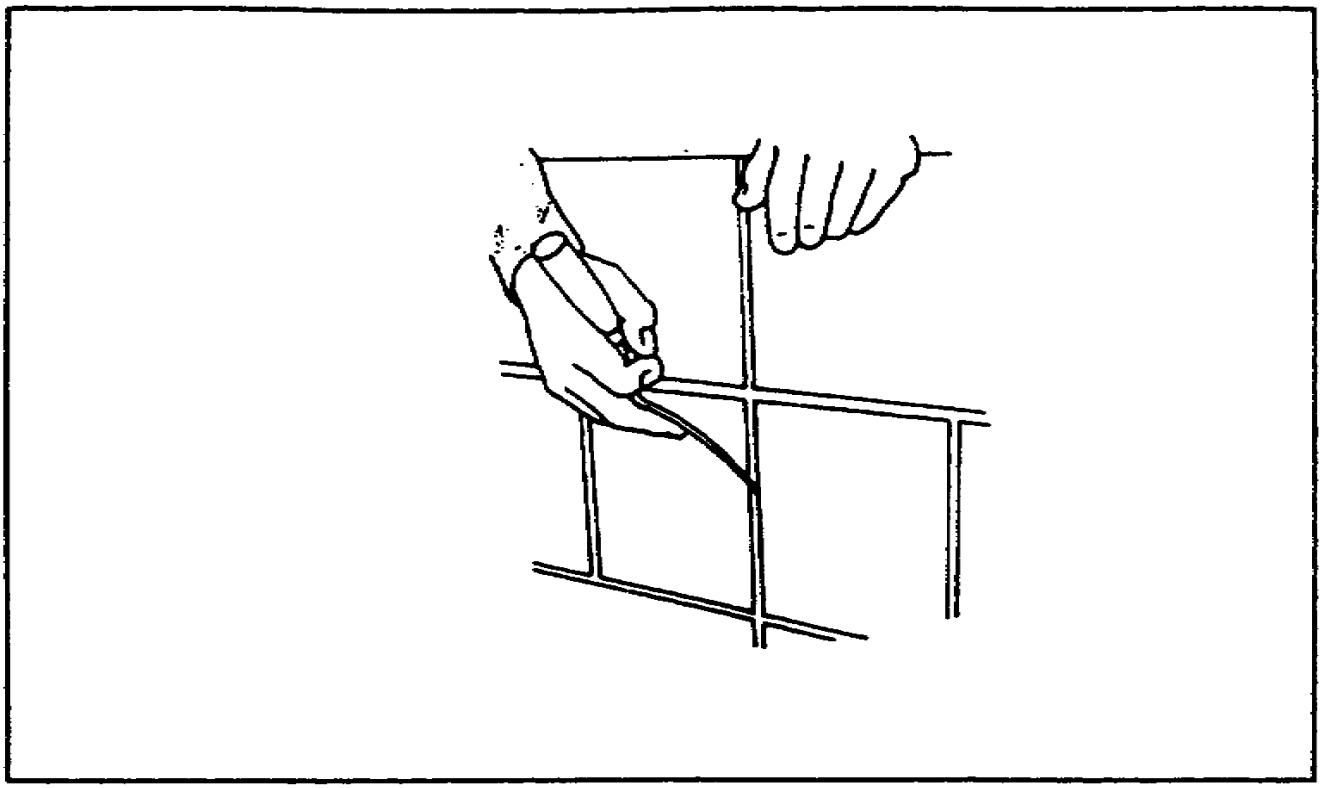

Figure 2-13. Raking mortar from the joints

PART F - LAYING UP THE CORNERS

After the first course of blocks are laid, build up the corners of the wall next, usually four or five courses higher than the first course. As you lay up the corners, cut each course back one-half block.

2-15. Applying Mortar. For the horizontal joints, apply mortar only to the tops of the blocks already laid. You may apply mortar for the vertical joints to the vertical end of the block to be laid, to the vertical end of the block previously laid, or to both.

2-16. Using a Level. As you lay each course at the corner, check it with a mason's level for alignment. Make sure that the corner is level and plumb (Figure 2-14). Check each block carefully, making certain that the faces of the blocks are all on the same plane. This will ensure true and straight walls.

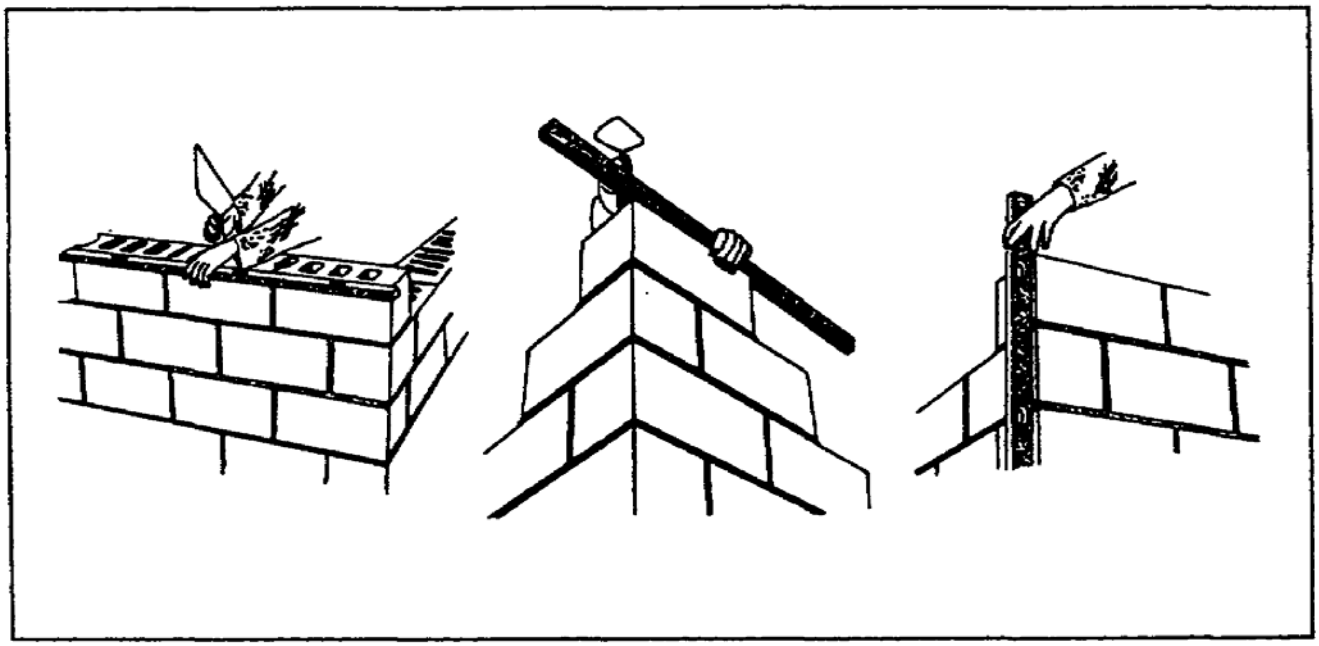

Figure 2-14. Aligning, leveling, and plumbing

2-17. Using a Story Pole. Use a story or course pole (a board with markings 8 inches apart) to determine the height of the wall for each course (Figure 2-15).

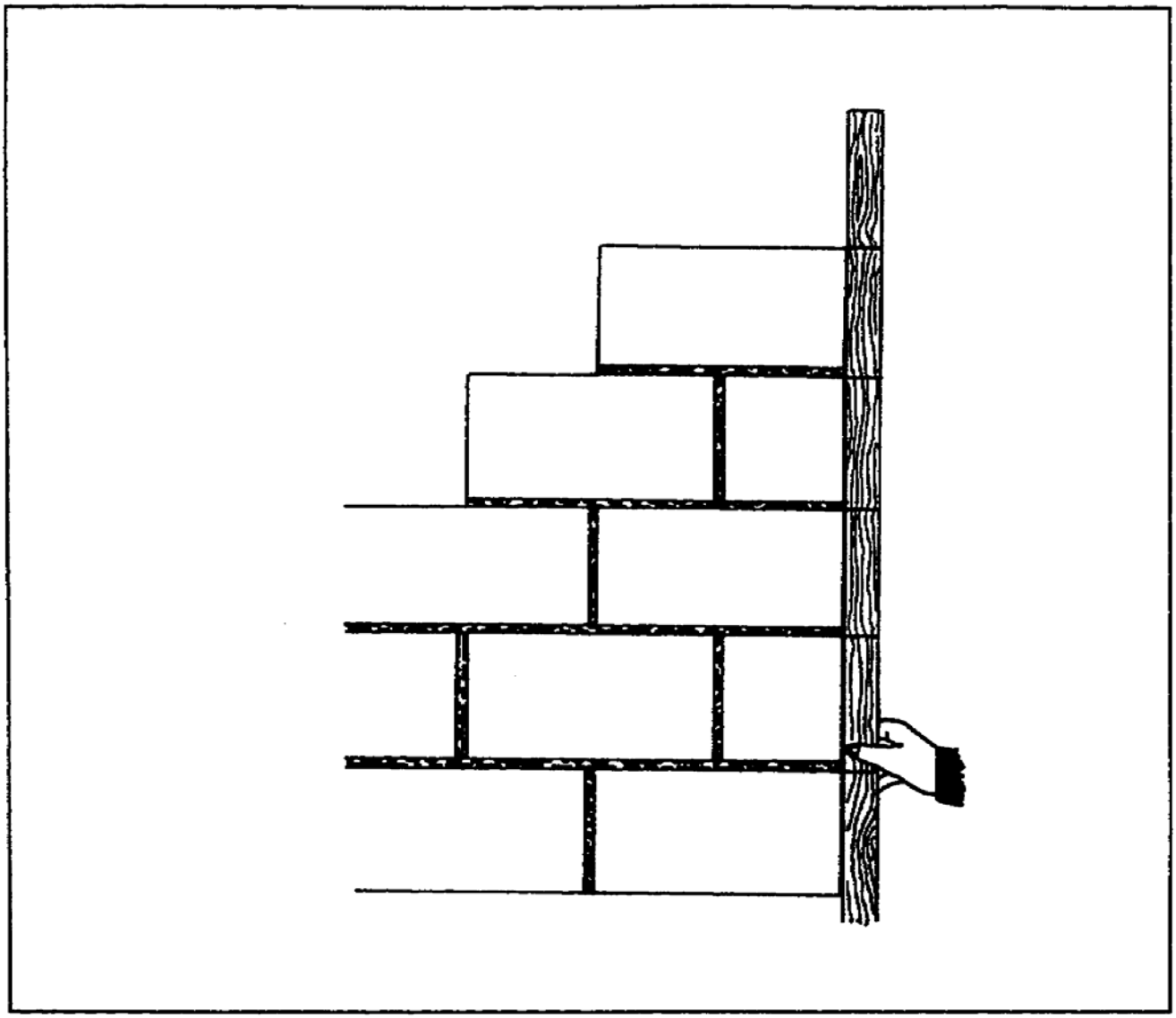

Figure 2-15. Using a story or course pole

PART G - LAYING CONCRETE BLOCKS BETWEEN CORNERS

To ensure a good bond, do not spread mortar too far ahead of the actual laying of the block. When mortar is allowed to sit, it will stiffen and lose its plasticity. As each block is laid, cut off excess mortar with your trowel and work it back into the fresh mortar (Figure 2-16).

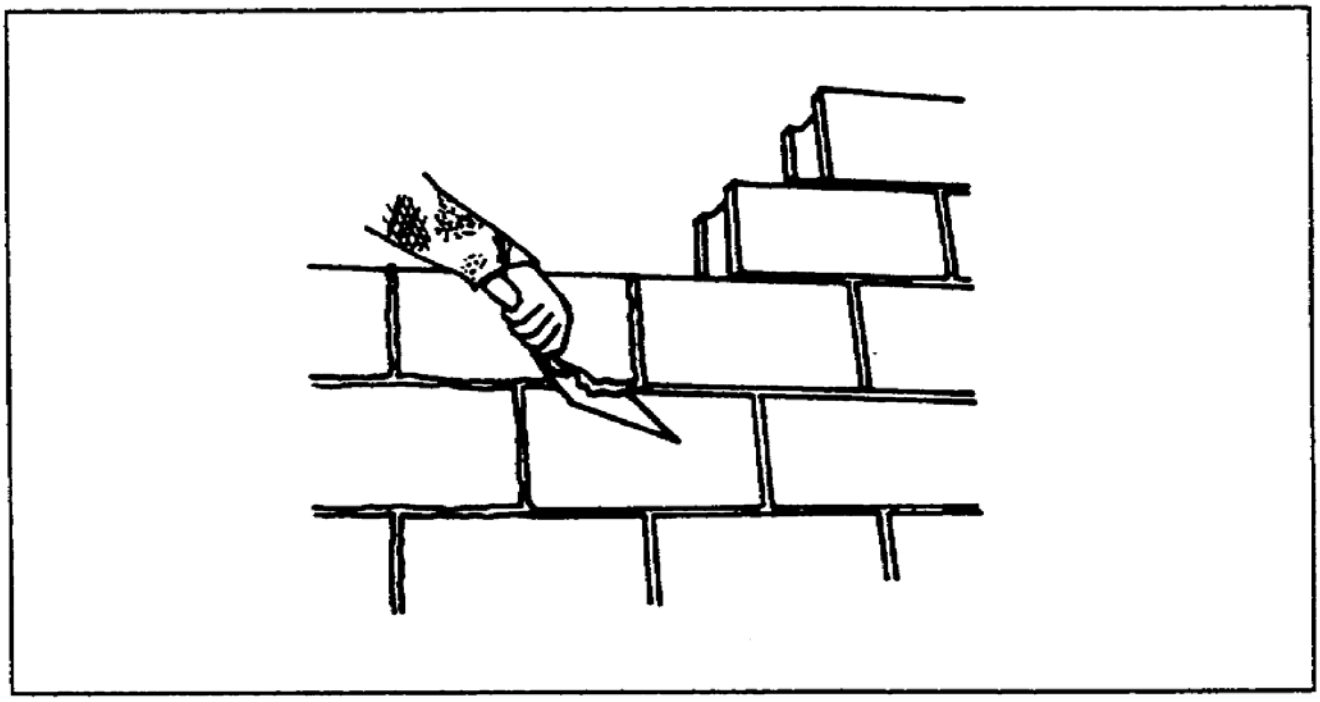

Figure 2-16. Cutting off excess mortar

2-18. Using a Mason's Line. As you fill in the wall between the corners, stretch a mason's line from corner to corner for each course. Lay the top outside edge of each block to his line. Tip the block slightly toward you so you can see the edge of the course below, making sure that the lower edge of the block is directly over the course below (Figure 2-17, page 2-20).

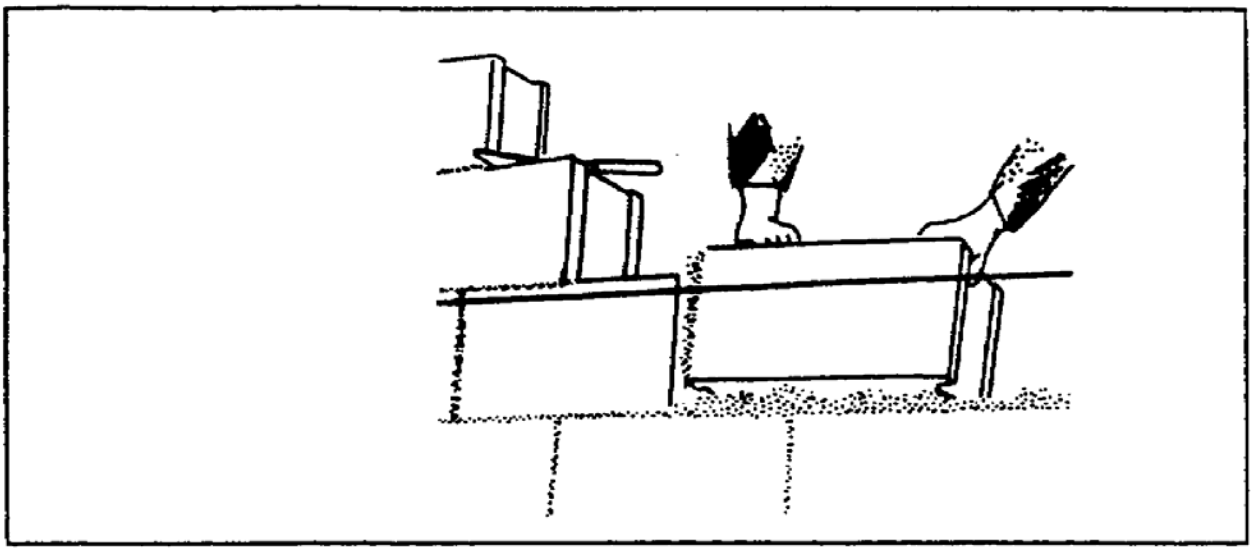

Figure 2-17. Laying the top outside edge of the block to the line

2-19. Making Adjustments. You must make all adjustments to the final position of the block while the mortar is flexible. If you try to make adjustments after the mortar has stiffened, it will break the mortar bond and allow water to penetrate. Level and align each block to the mason's line by tapping it lightly with the trowel handle.

2-20. Installing the Closure Block. The last block to be installed in every course is called the closure block. When you install the closure block butter all edges of the opening in the wall and all four vertical edges of the closure block with mortar. Carefully lower the block into place. If any mortar falls out and leaves an opening in the joint, remove the block and repeat the procedures (Figure 2-18).

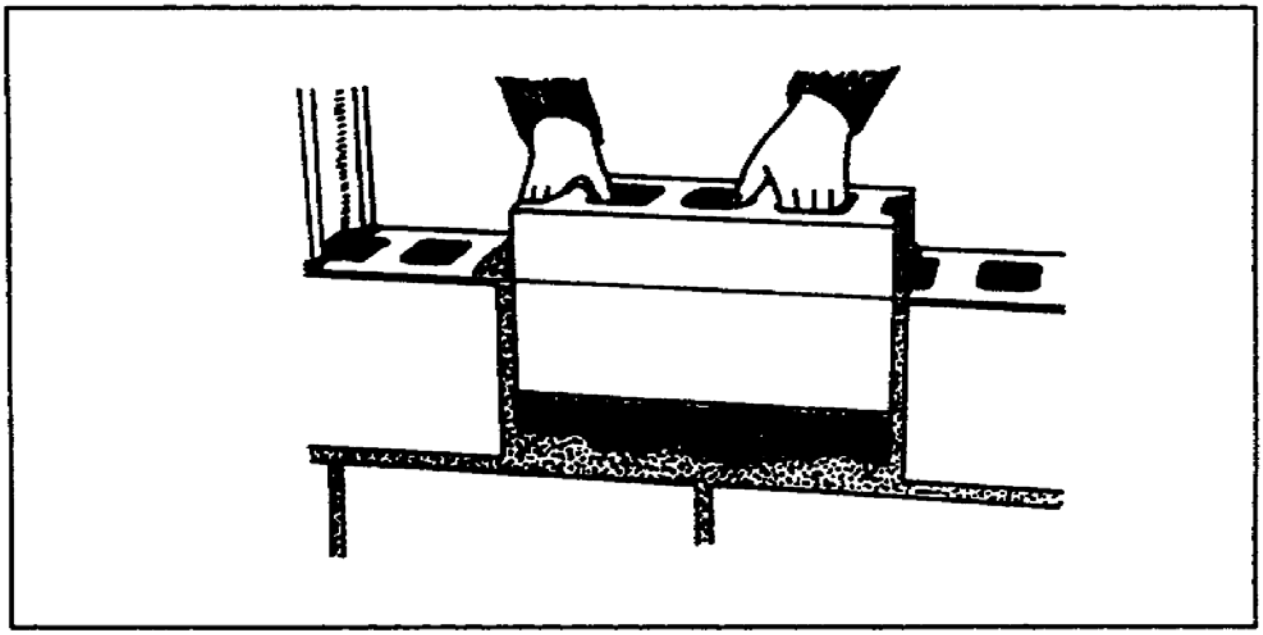

Figure 2-18. Installing the closure block

PART H - TOOLING THE JOINTS

Proper tooling of mortar joints helps produce a weathertight, neat, and durable concrete-block wall. For exterior concrete, the mortar joints you make should be concave or V-joints (Figure 2-19). Tool the vertical jointer first, followed by the horizontal joints with a longer jointer.

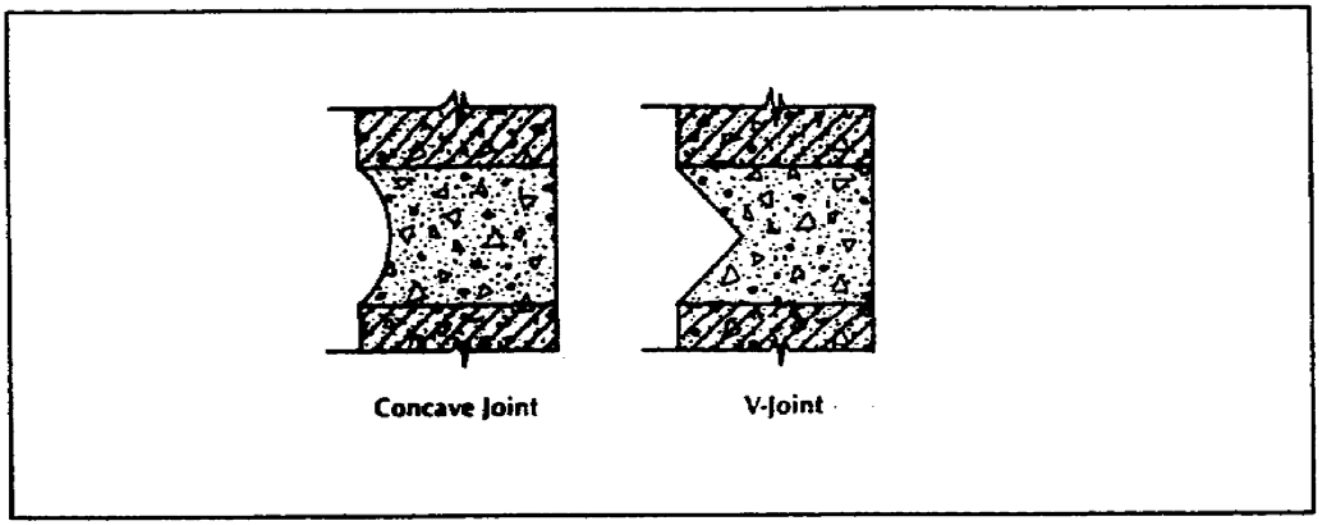

Figure 2-19. Mortar joints

2-21. Jointers. To finish mortar joints, you will use a jointer, also called a finishing tool (Figure 2-20).

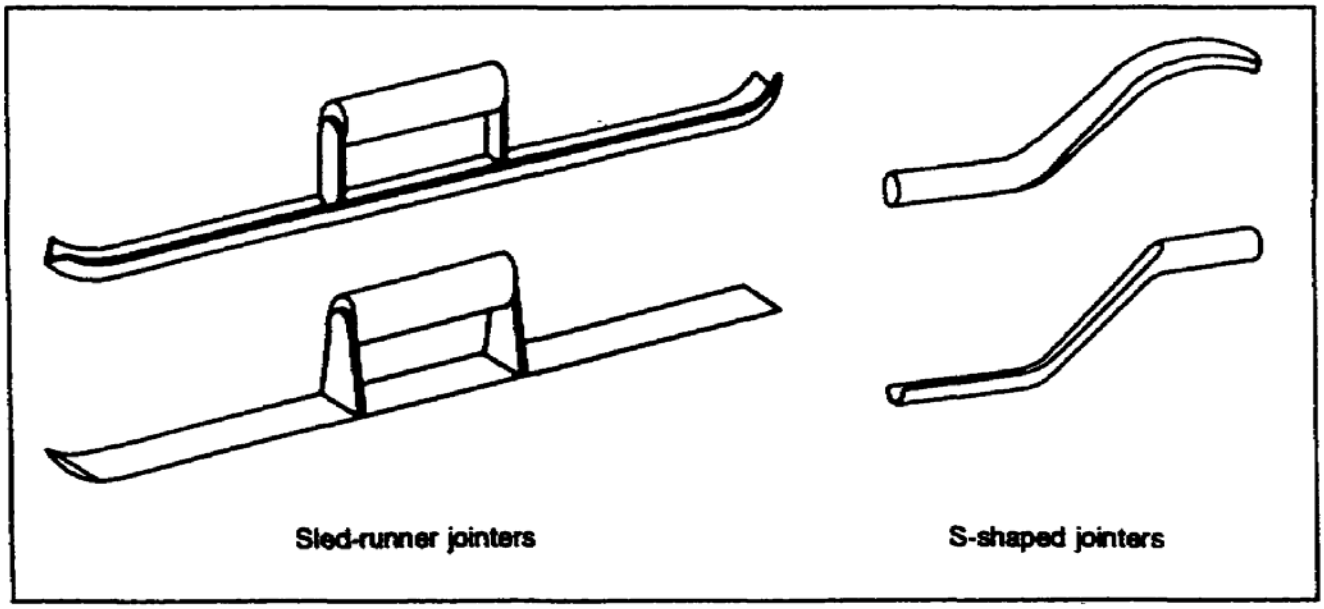

Figure 2-20. Jointers

a. Sled Runner. Use a sled-runner jointer to tool horizontal joint (Figure 2-21).

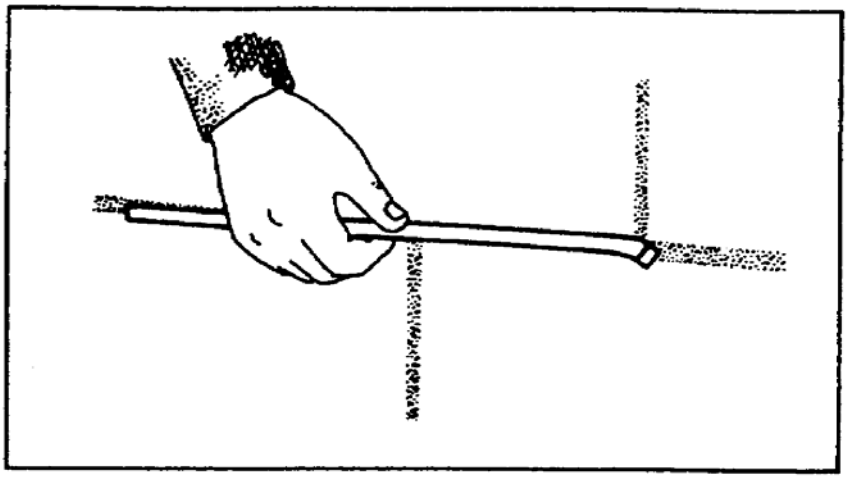

Figure 2-21. Tooling horizontal joints

b. S-shaped. Use the S-shaped jointer to tool vertical joints (Figure 2-22). This is called striking.

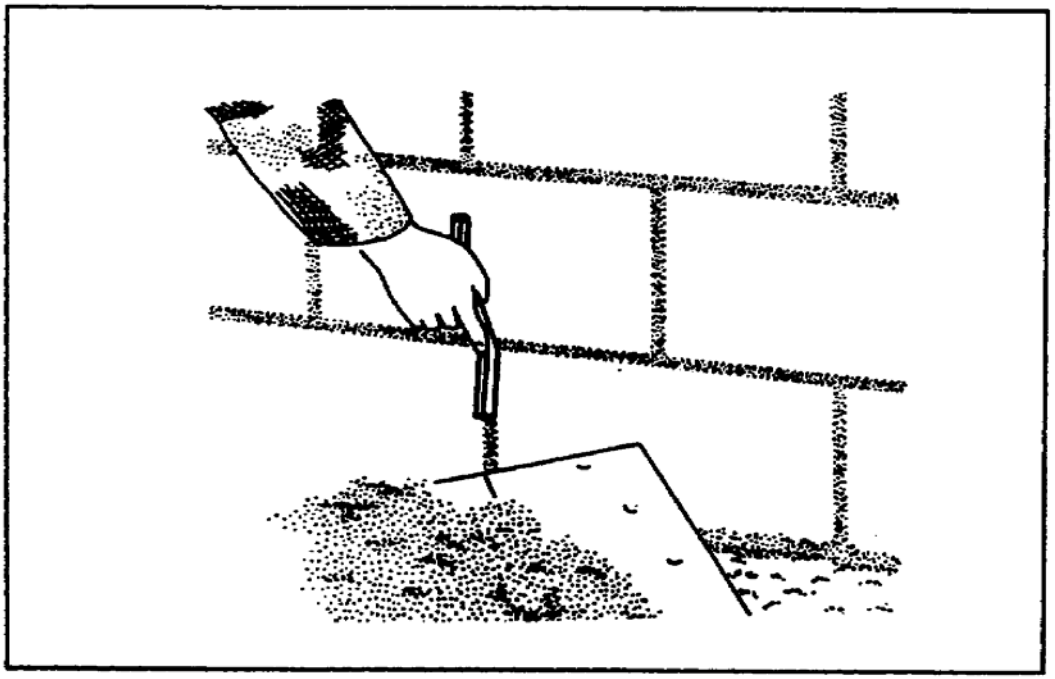

Figure 2-22. Striking vertical joints

2-22. Burrs. You can reduce burring by finishing the horizontal mortar joints before you finish the vertical joints. If mortar burrs remain on the wall after you have finished tooling, you should remove them. This will prevent small amounts of water from being lodged in the mortar joint.

PART I - INTERSECTING WALLS

Depending on the type of wall, intersecting walls are tied together with tie bars or meal laths.

2-23. Bearing Walls. Bearing walls or blocks in intersecting load-bearing walls should not be interlocked in a bond. Instead, terminate one wall at the face of the other with a control joint at the point where they intersect.

a. Placing Tie Bars. Tie bearing walls together with a tie bar that has a right angle bend on each end. Place a metal lath over the core in the outside wall to support the concrete or mortar for the next course (Figure 2-23).

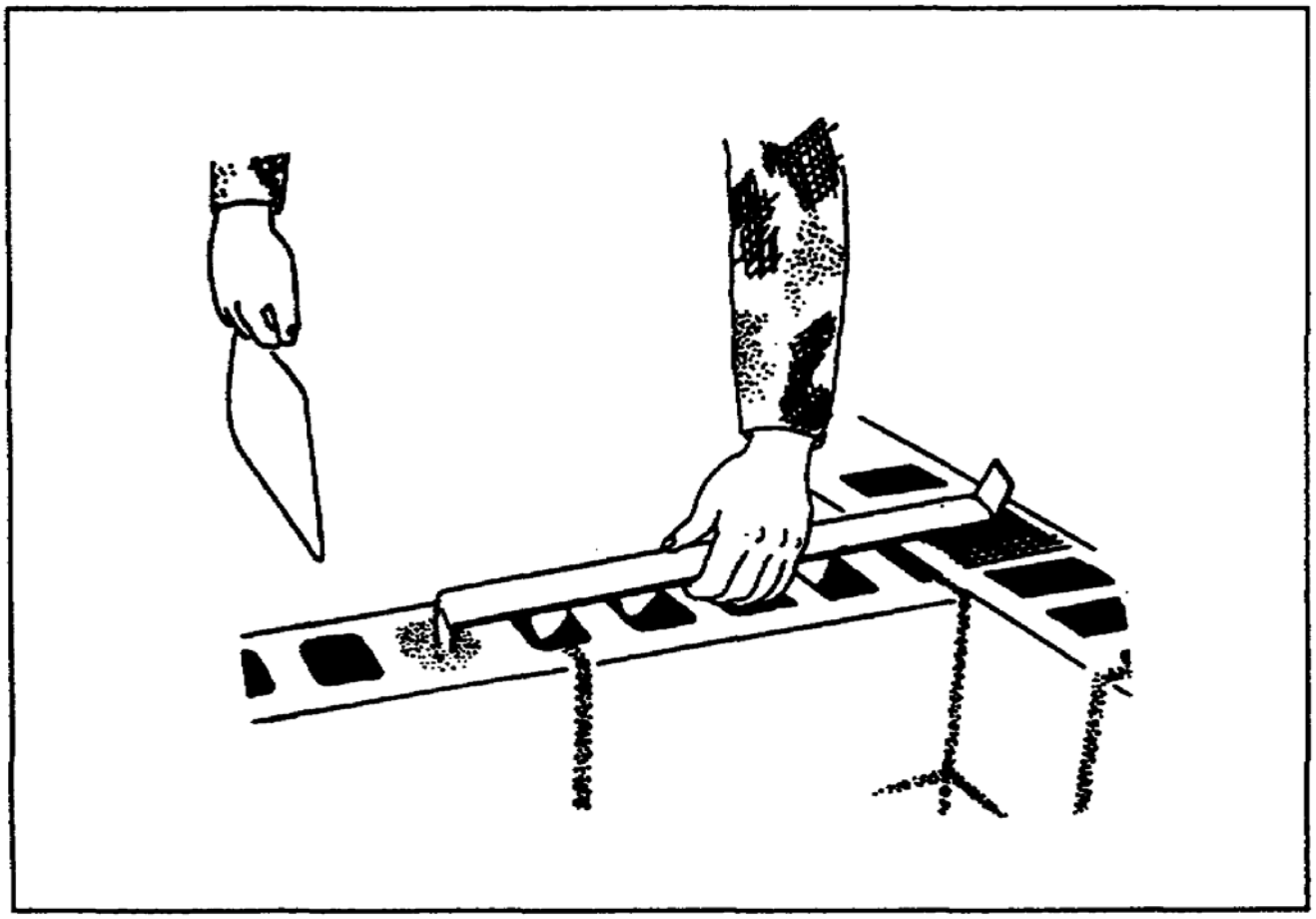

Figure 2-23. A tie bar and metal lath

b. Spacing Tie Bars. Space tie bars no more than 4 feet apart vertically. Fill the core of the block with mortar or concrete and embed the right angle bend of the tie bar in the core (Figure 2-24).

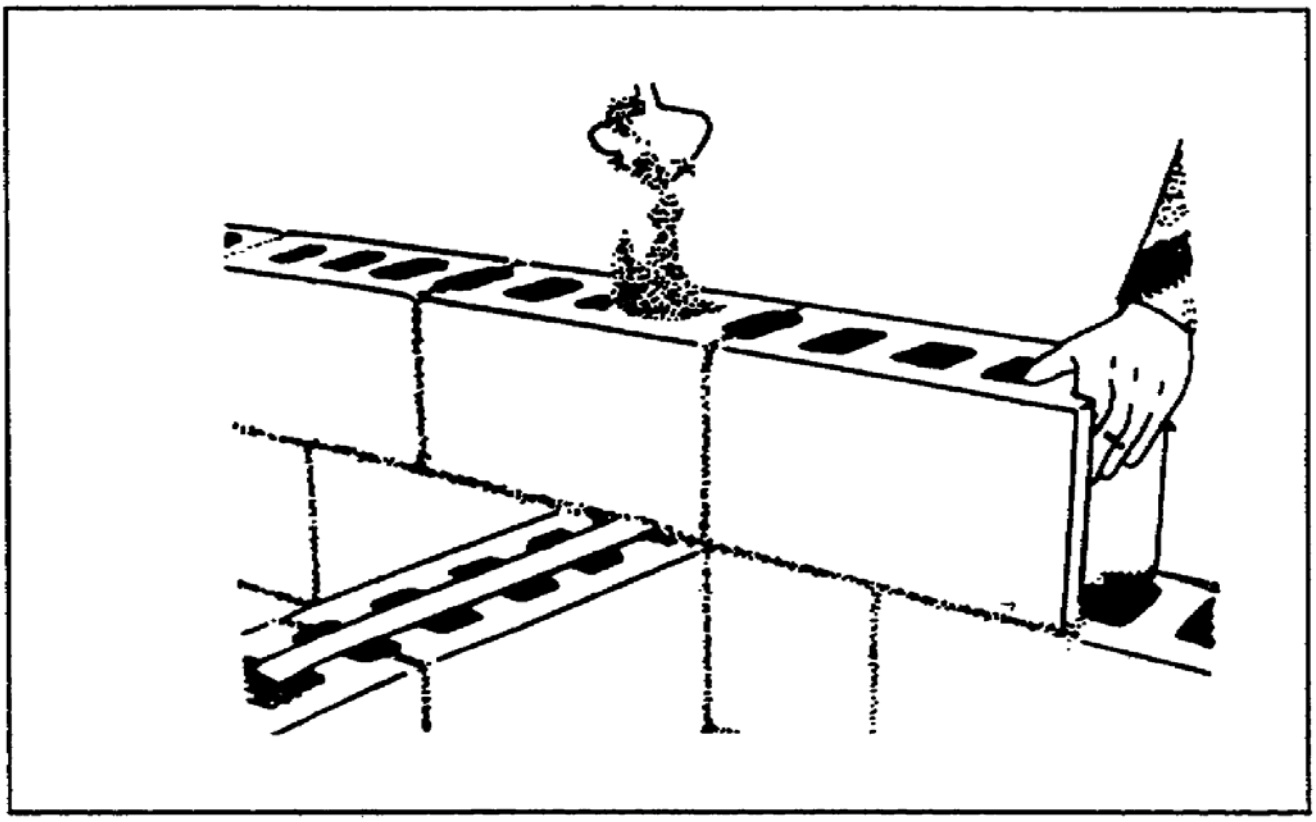

Figure 2-24. Filling the core with mortar

2-24. Nonbearing Walls. To tie nonbearing walls to other walls, place metal-lath strips across the joints in alternate courses between the two walls (Figure 2-25). If one wall is constructed first, build the metal laths into the first wall. Later, tie the metal laths into the mortar joints of the second wall and construct control joints where the two walls meet (Figure 2-26, page 2-26).

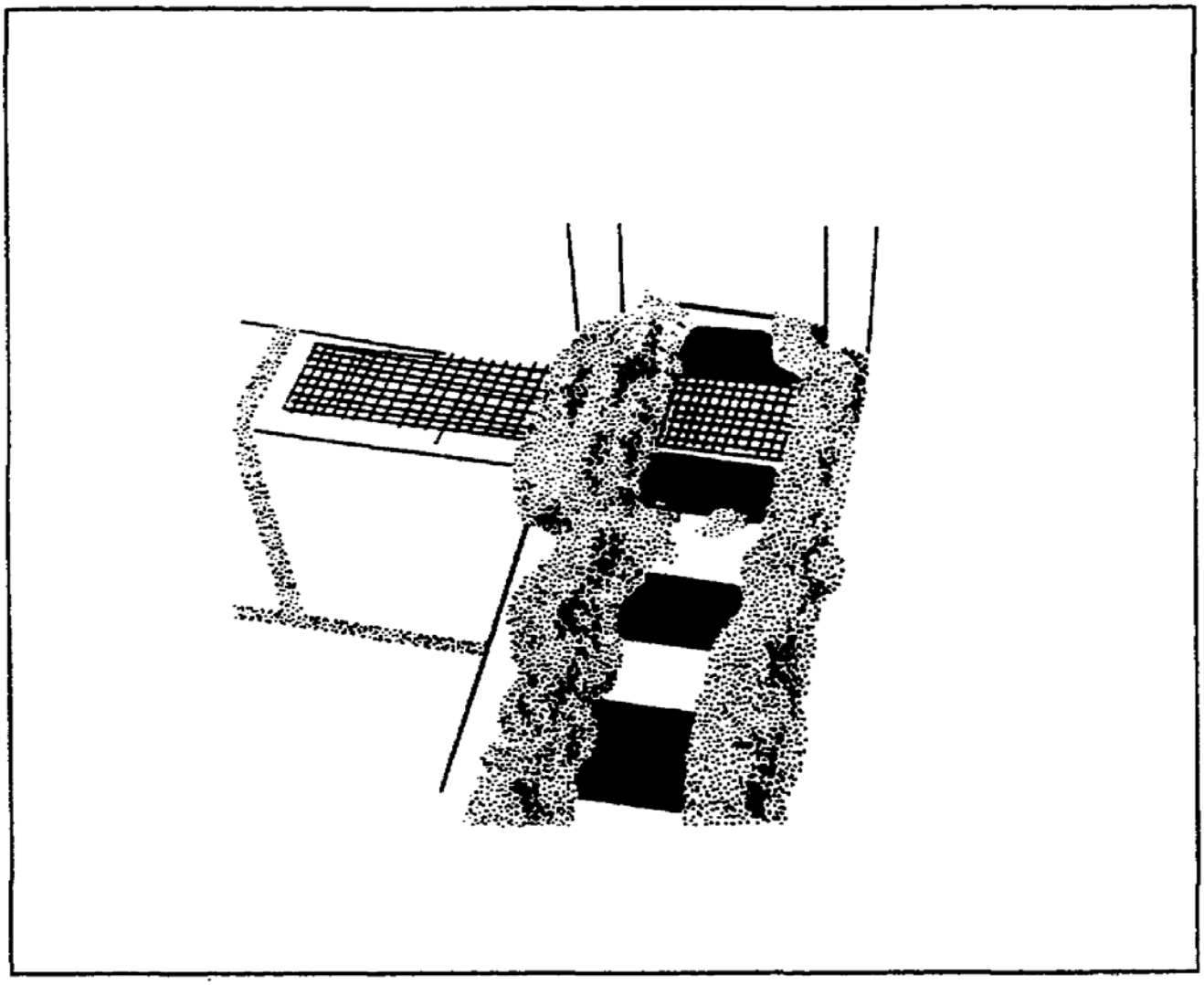

Figure 2-25. Metal lath spanning the joint

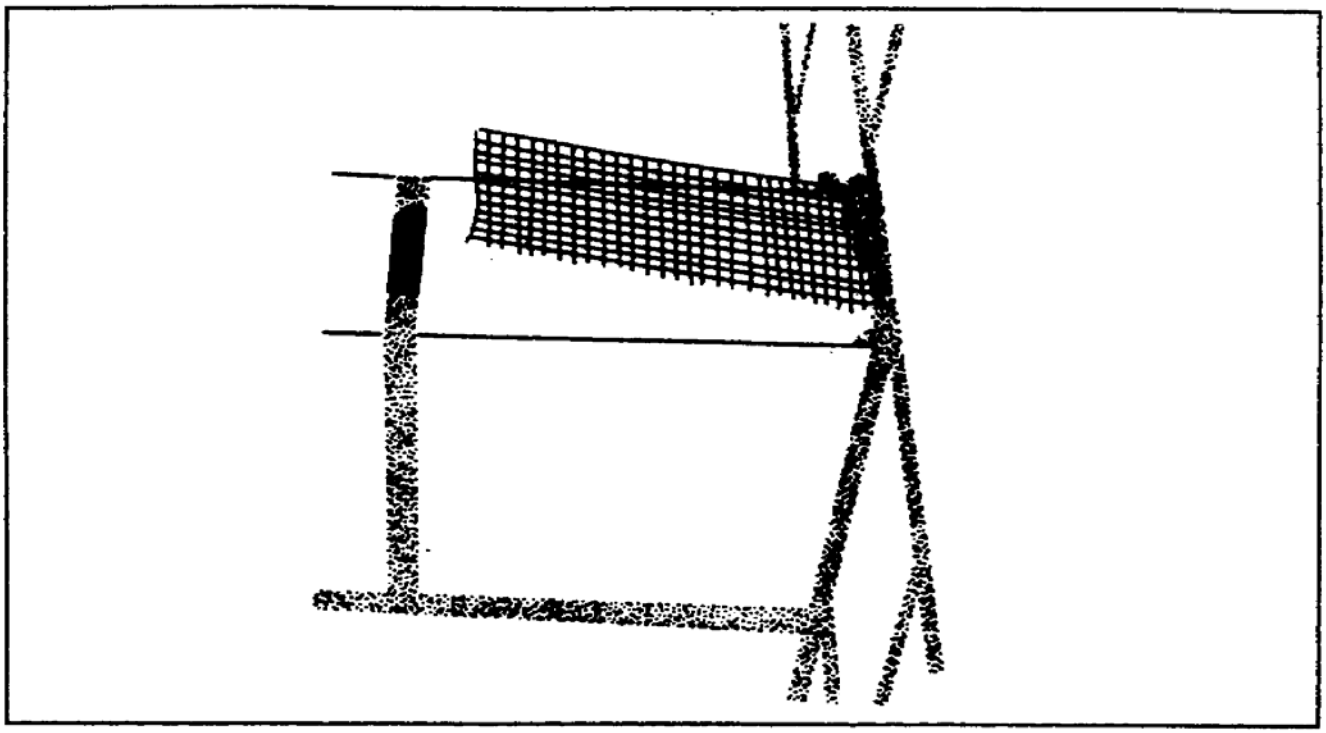

Figure 2-26. Metal lath built into the first wall

PART J - ANCHOR BOLTS

To fasten top plates to the top of concrete-block walls, you must use anchor bolts.

2-25. Spacing of Anchor Bolts. Anchor bolts should be spaced no more than 4 feet apart. Place a metal lath in the second horizontal mortar joint from the top of the wall wherever you plan to install an anchor bolt (Figure 2-27).

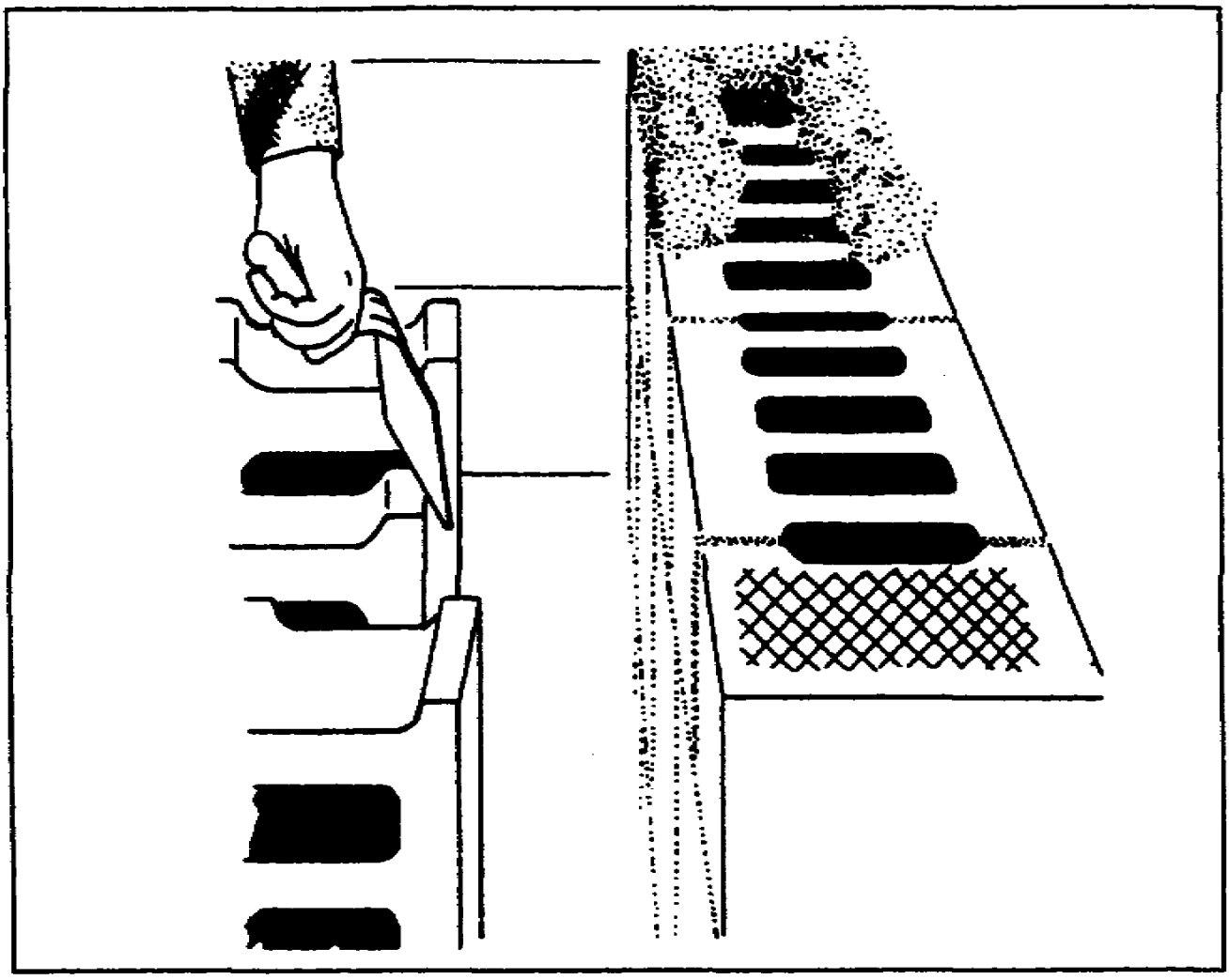

Figure 2-27. Placing metal lath

2-26. Installing Anchor Bolts. In the top course of the wall, place the bolts in the cores of the selected blocks. Fill these cores with concrete or mortar, and extend the threaded end of the bolt above the top of the wall (Figure 2-28, page 2-28). Attach the top plates to the anchor bolts after the mortar has set.

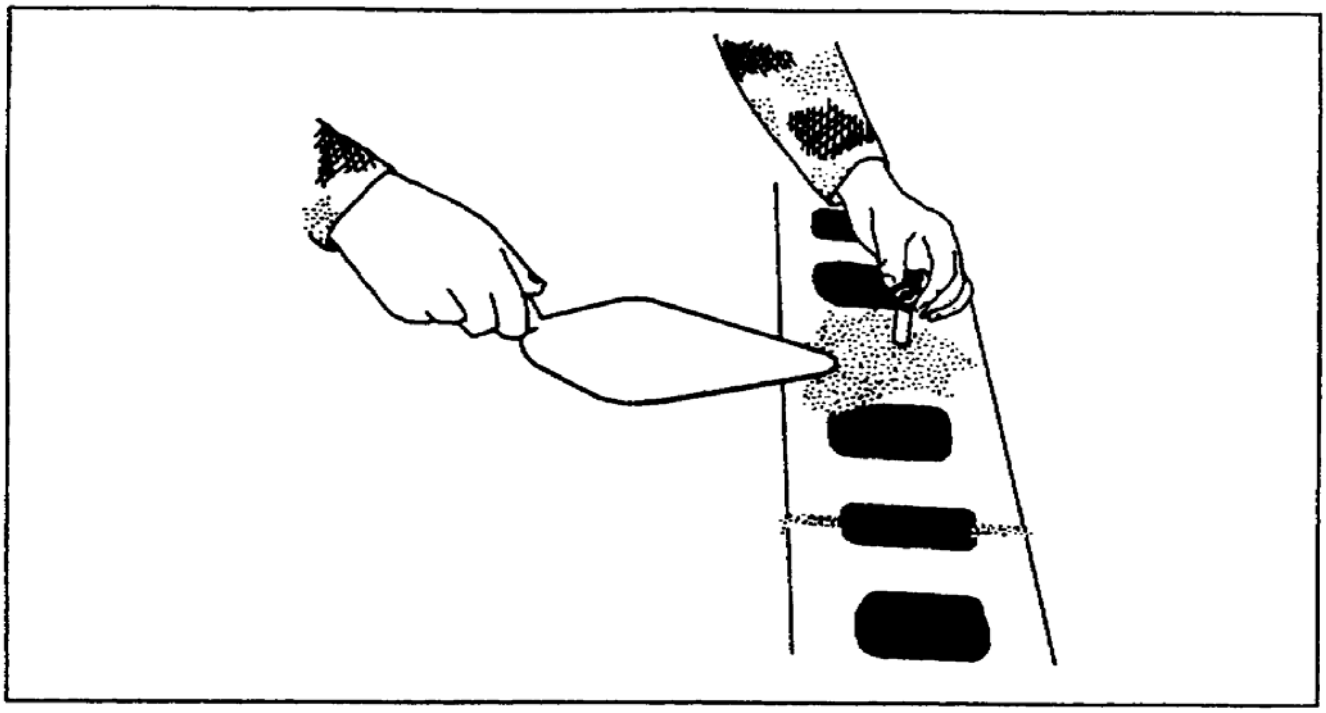

Figure 2-28. Installing anchor bolts in the top course of the wall

PART K - LINTELS, SILLS, AND REINFORCING STEEL

Lintels, sills, and reinforcing steel are frequently used in construction.

2-27. Lintels. Lintels are placed across the top of door and window openings to support the walls above the openings. Precast concrete lintels are often used over door and window openings (Figure 2-29).

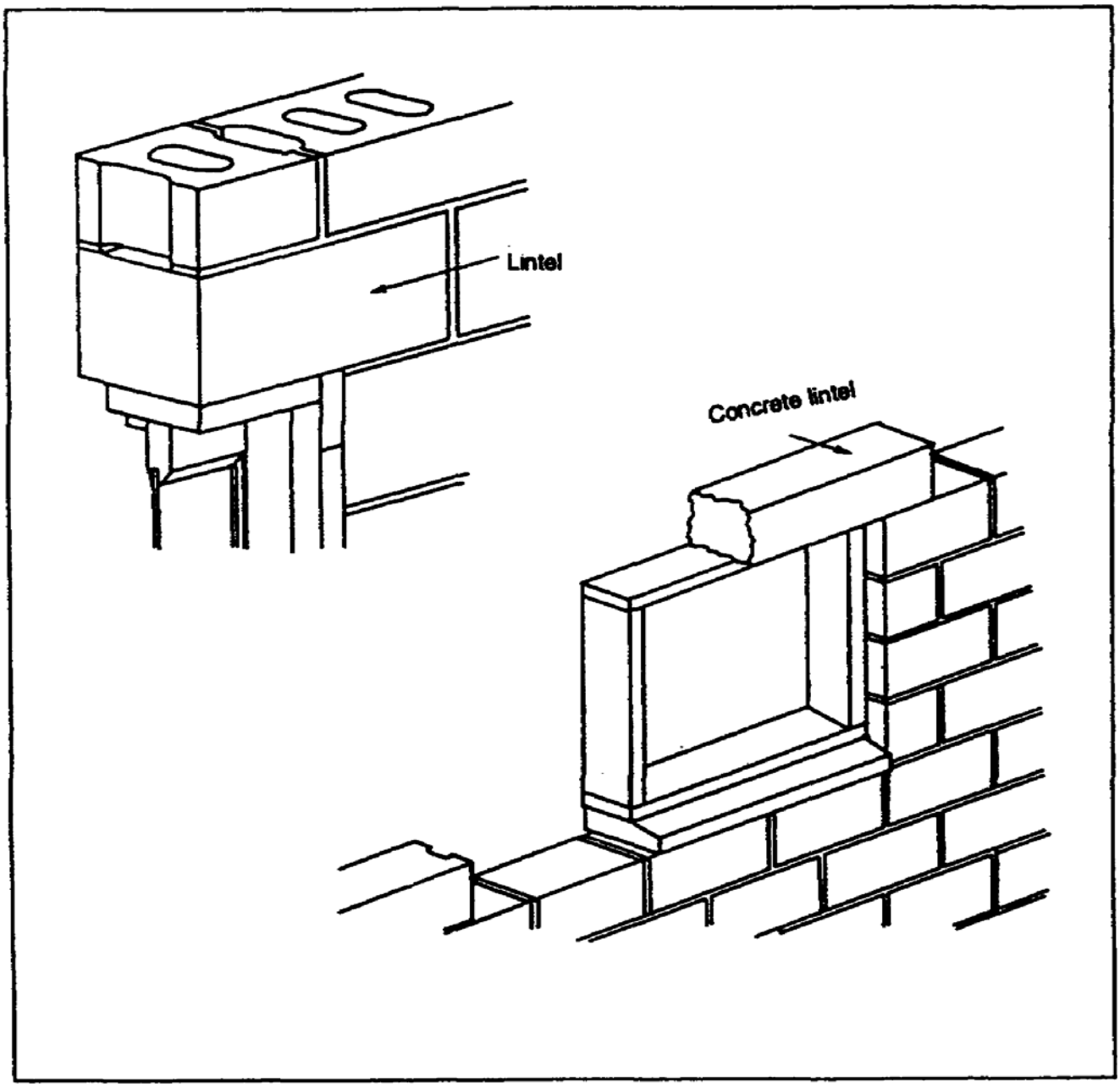

Figure 2-29. Precast lintels without offset

a. Offset Lintels. For modular window and door openings, you will often use precast concrete lintels designed with an offset on the underside. Steel angles are also used with lintels to support blocks over openings. You must install the blocks with the offset on the underside to fit modular openings (Figure 2-30).

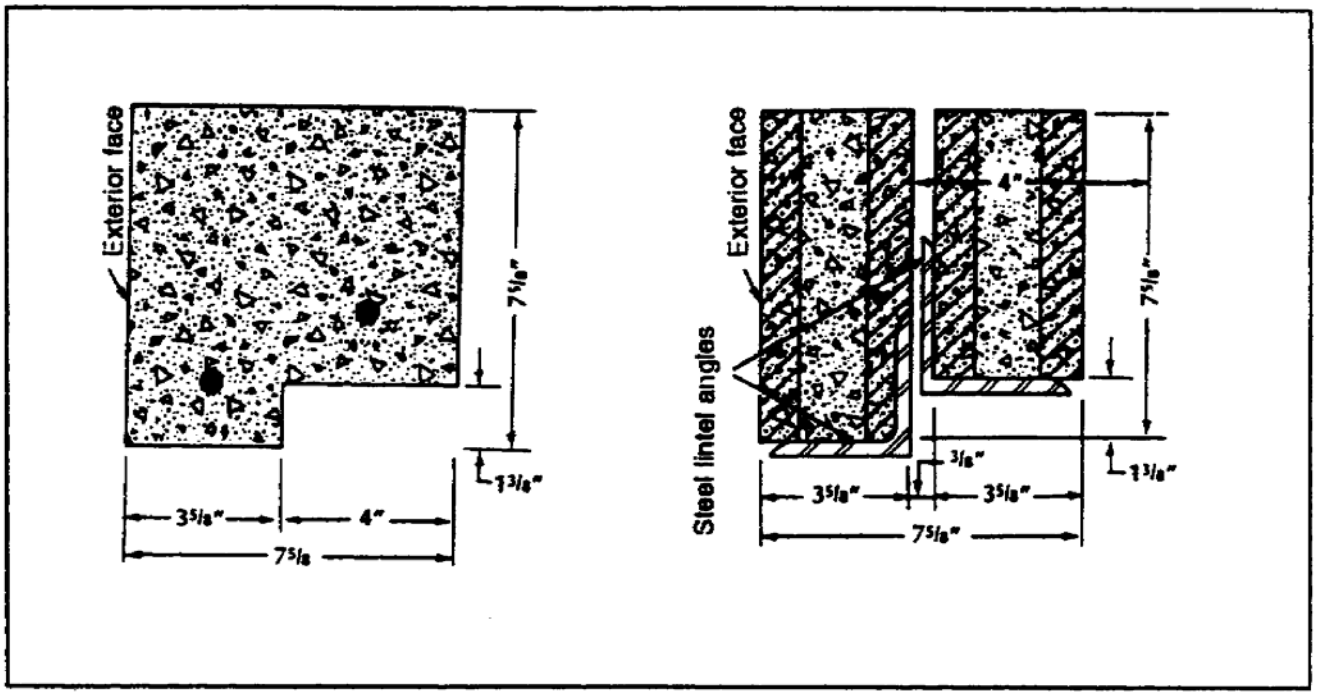

Figure 2-30. Precast concrete lintels with an offset

b. Metal Pates. Place a noncorroding metal plate under the ends of lintels wherever there are control joints. This permits lintels to give slightly and helps the control joints to function properly. Place a full bed of mortar over this metal plate to distribute the lintel load evenly.

2-28. Sills. You will usually install precast concrete sills after you have built the walls. Be sure to tightly fill the joints at the ends of the sill with mortar or a caulking compound (Figure 2-31).

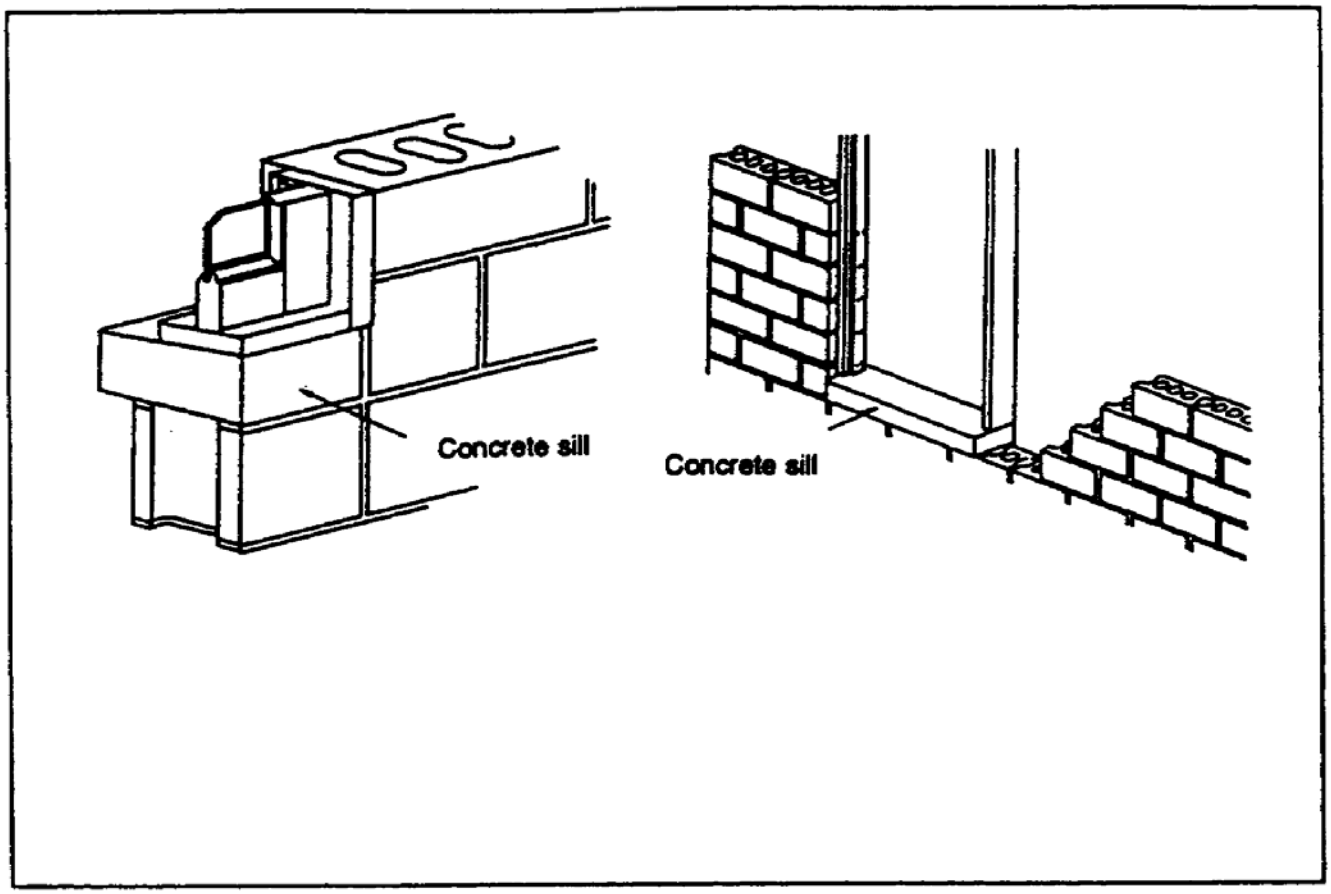

Figure 2-31. Precast concrete sills

2-29. Reinforcing Steel. You can use steel bars to reinforce lintels and beams and to support the wall against abnormal stresses, such as an earthquake or strong winds.

a. Lintels and Beams. Lintel blocks can be used for constructing reinforced block beams or lintels. Lay the blocks end to end to form a channel. Place reinforcing bars in the channel and then fill the channel with concrete or mortar. You can either cast the beam or lintel in place on the shoring or precast and install it later (Figure 2-32).

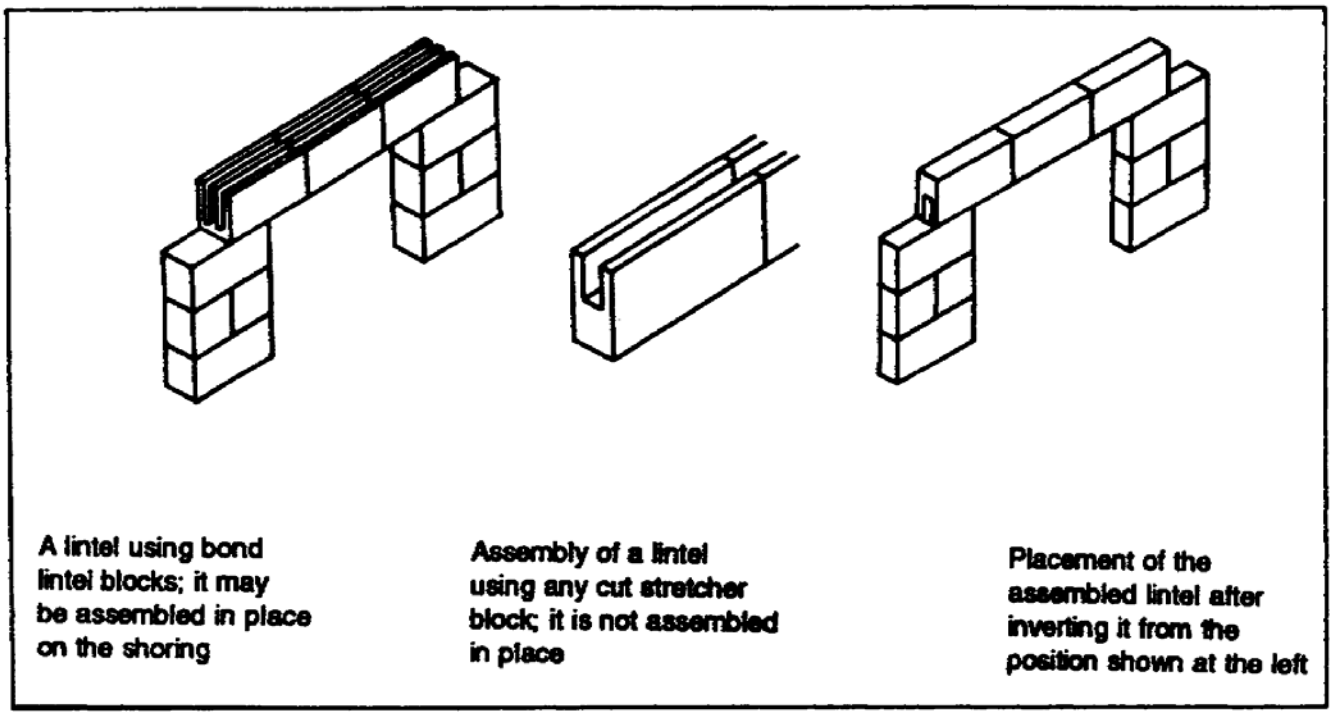

Figure 2-32. Lintels made with concrete blocks, mortar, and reinforcing steel bars

b. Vertical Steel. Use vertical steel bars in the corners and around door and window openings. Figure 2-33 shows the placement of both vertical and horizontal steel reinforcing bars.

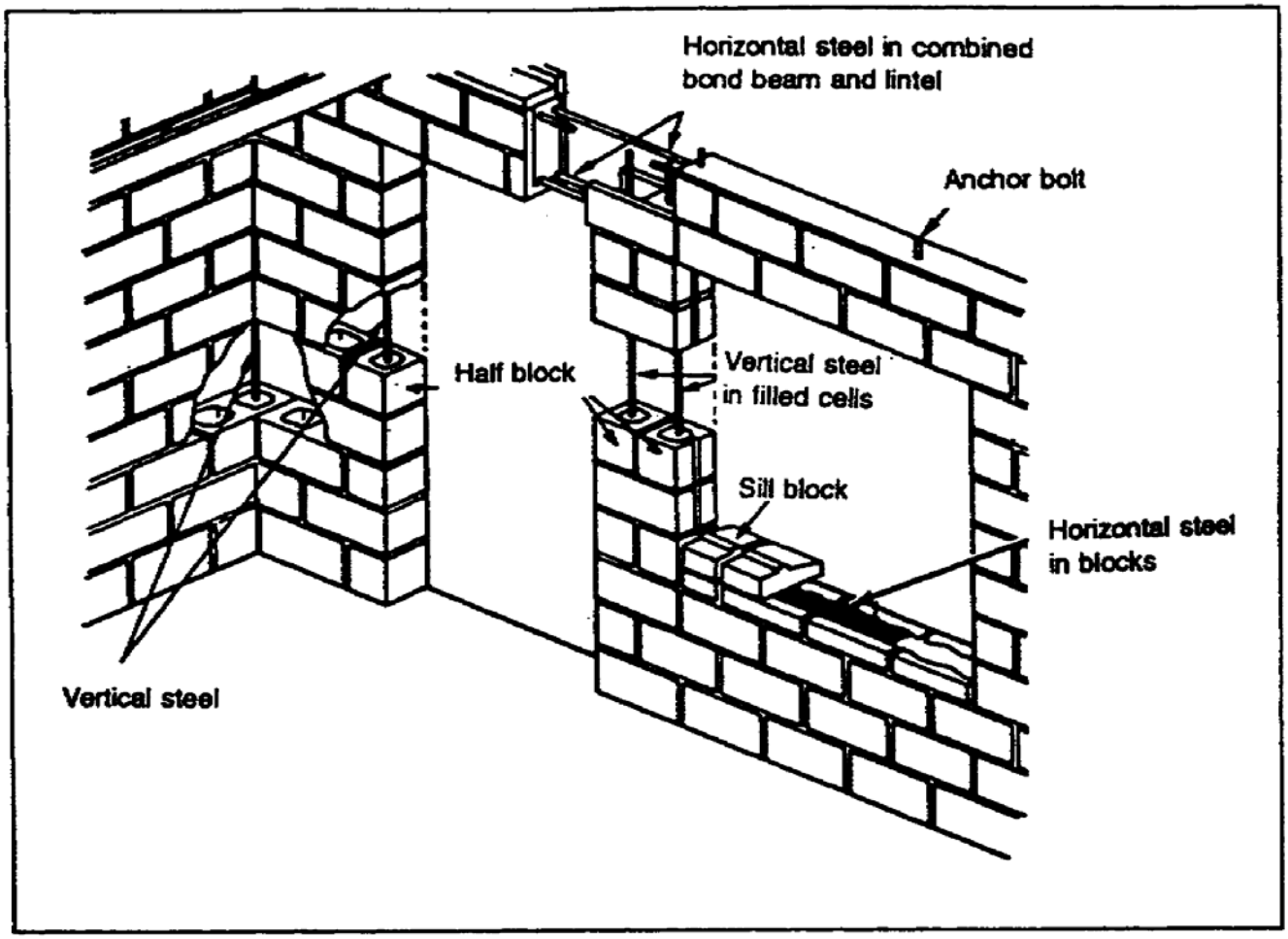

Figure 2-33. Placing reinforcing steel

PART L - PATCHING AND CLEANING CONCRETE-BLOCK WALLS

Be careful not to smear mortar on the blocks. Once it has hardened, you cannot remove it, and paint will not always hide the smear. If you drop any mortar while laying the blocks, let it dry exactly as it falls and then try to remove it by striking it with a small piece of broken concrete block (Figure 2-34) Concrete-block was should never be cleaned with acid. If you need to patch mortar joints or fill holes left by nails or line pins, always use fresh mortar.

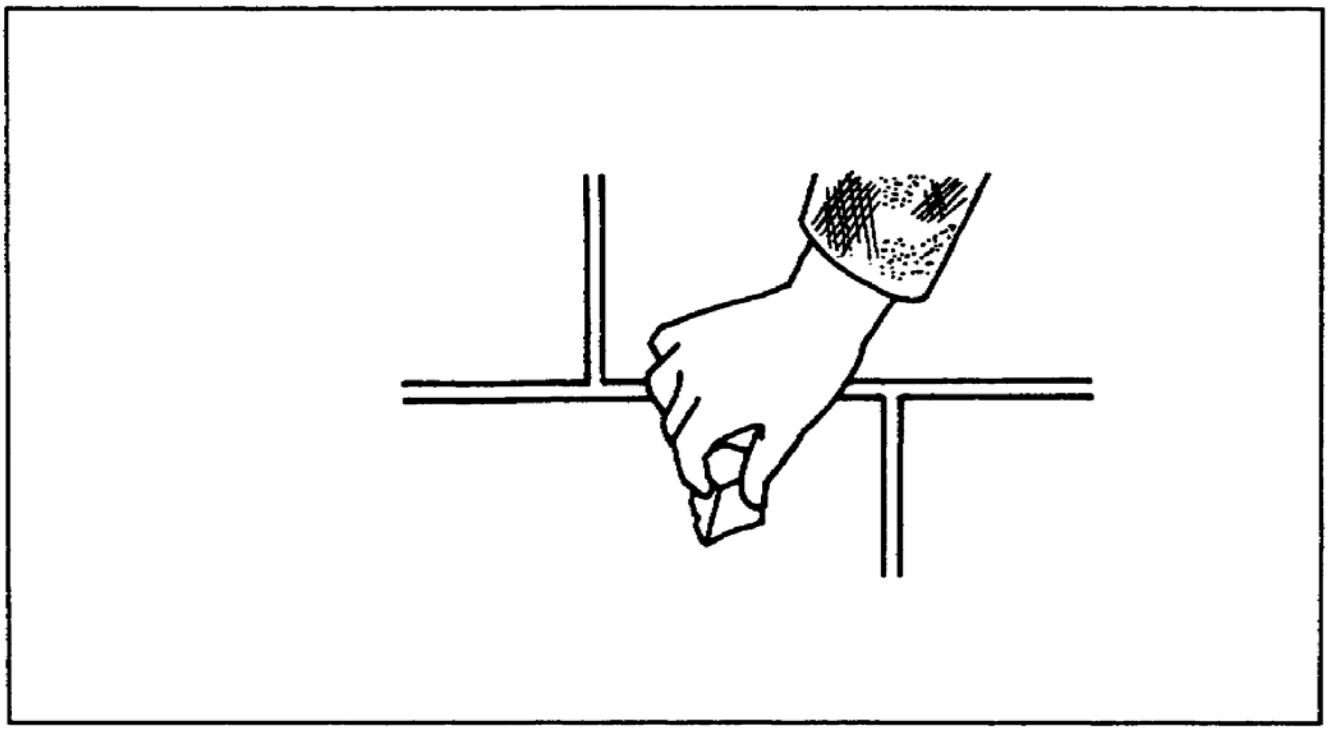

Figure 2-34. Removing dried mortar with a piece of broken block

LESSON 2

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer to each item. When you complete the exercise, check your answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

1. Which concrete block is the most commonly used in construction?

   A. The stretcher
   B. The corner
   C. The lintel
   D. The jam

2. Why is it necessary to lay the stretcher block with the thicker side of the face shell up?

   A. To allow the next course of block to set plumb
   B. To allow for a wider mortar joint
   C. To allow for a greater mortar bedding area
   D. Because heavyweight blocks are used in load-bearing walls

3. You are constructing a concrete block wall. In which course would you place a closure block?

   A. Every course
   B. Every other course
   C. Every third course
   D. The top course

4. What tool should you use to finish vertical joints?

   A. A joint rake
   B. A sled runner jointer
   C. A S-shaped jointer
   D. A trowel

5. What is the maximum spacing, in feet, between anchor bolts?

   A. 2
   B. 4
   C. 6
   D. 8

6. In construction, what are lintel blocks used for?

   A. Window frames
   B. Door frames
   C. Sills
   D. Beams

7. How many vertical edges are buttered when installing a closure block?

   A. 1
   B. 2
   C. 3
   D. 4

8. What should you use to tie bearing walls to intersecting walls?

   A. Tie bars
   B. Masonry bonds
   C. Mortar joints
   D. Tie beams

9. When constructing a wall, which block should you lay first?

   A. The stretcher
   B. The closure
   C. The corner
   D. The jamb

10. How high should the control joint extend in a concrete block wall?

    A. To the third course
    B. To the sixth course
    C. To the ninth course
    D. To the top course

11. In inches, how deep should you rake a control joint?

    A. 1/4
    B. 1/2
    C. 3/4
    D. 1

12. What is a story pole used for in construction of a concrete-block wall?

    A. To determine the height of the wall for each course
    B. To determine the amount of blocks in a course
    C. To check the thickness of mortar joints
    D. To help keep the wall plumb

LESSON 2

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		Correct Answer and Feed Back	
1.	A.	Stretcher A stretcher block is the ….	(page 2-3, para 2-5a)
2.	C.	To allow for a greater mortar bedding area Be sure to lay all blocks with the thicker ….	(page 2-11, para 2-9)
3.	A.	Every course The last block to be installed ….	(page 2-20, para 2-20)
4.	C.	S-Shaped jointer Use the S-shaped jointer ….	(page 2-22, para 2-21b)
5.	B.	4 Anchor bolts should be spaced ….	(page 2-27, para 2-25)
6.	D.	Beams Lintel blocks can be used for ….	(page 2-32, para 2-29a)
7.	D.	4 When you install the closure block ….	(page 2-20, para 2-20)
8.	A.	Tie bars Tie bearing walls together with a tie bar ….	(page 2-23, para 2-23a)
9.	C.	Corner Lay the corner block first ….	(page 2-11, para 2-9)
10.	D.	Top curse They are usually spaced at ….	(page 2-14, part E Intro)
11.	C.	3/4 When the mortar in the control ….	(page 2-15, para 2-14)
12	A.	To determine the height of each course You should use a story or course pole ….	(page 2-18, para 2-17)

LESSON 3

CONSTRUCT A BRICK WALL

Critical Task 051-236-1146

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn how to lay out and construct a brick wall.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will learn how to lay out and construct a brick wall.

CONDITION: You will use the materials contained in this lesson.

STANDARD: You will correctly answer practice exercise questions at the end of this lesson.

REFERENCES: The materials contained in this lesson were derived for FM 5-426, FM 5-742, STP's 5-51B12-SM-TG, and materials approved for instruction by the US Army Engineer School.

INTRODUCTION

As a carpenter/mason, you will be expected to lay out and construct a brick wall. You must be able to design and construct structures that are safe and structurally sound. A major par of that responsibility is to choose the best materials available to accomplish this task.

PART A - TYPES AND CHARACTERISTICS OF BRICKS

A brick is a structural unit made from various kiln-baked clay and shale mixtures. Bricks are produced in a variety of colors and hardness by varying the clay/shale mixtures and the kiln temperature. They can be solid, hollow, or architectural terra cotta. Individual bricks may serve a structural function, a decorative function, or both.

3-1. Sizes. The standard-size brick manufactured in the US is 2 1/4 by 3 3/4 by 8 inches. Other brick types include the English (3 by 4 1/2 by 9 inches), the Roman (1 1/2 by 4 by 12 inches), and the Norman (2 3/4 by 4 by 2 inches).

3-2. Surfaces. The surface areas of a brick are the face, the cull, the side, the end, and the beds (Figure 3-1).

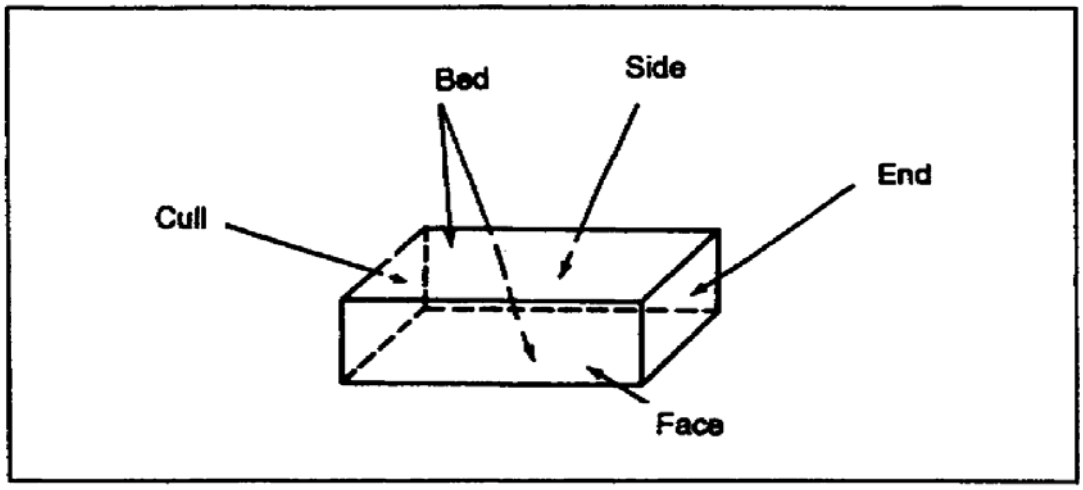

Figure 3-1. Surface area of a brick

3-3. Types of Bricks. Brick are used in various ways.

a. Building Bricks. Also called common, hard, or kiln-run bricks, these brick are made from ordinary clays or shales and fired in kilns. They have no special scorings, markings, surface texture, or color. Building bricks are generally used for the backing courses in solid and cavity brick walls.

b. Face Bricks. Face bricks are used in the exposed face of a wall. They are high quality, durable bricks with a nice appearance.

c. Clinker Bricks. Clinker brick are bricks that are over-burned in the kiln. They are usually hard, durable, and irregular in shape.

d. Pressed Bricks. The dry-press process is used rather than kiln firing to make pressed bricks, which have regular smooth faces, sharp edges, and perfectly square corners. Pressed bricks are generally used as face bricks.

e. Glazed Bricks. These bricks normally have one surface coated with a white or other color of ceramic glazing. Glazed bricks are often used for walls in hospitals, dairies, laboratories, or other buildings that are frequently cleaned.

f. Fire Bricks. Fire bricks are made to withstand high temperatures. They are placed in fireplaces and boilers because of their resistance to crack or decompose. Fire bricks are generally larger than regular structural bricks.

g. Cored Bricks. Cored bricks are made with two rows of five holes extending through the brick to reduce the weight.

h. Sand-Lime Bricks. These bricks are made from a mixture of lime and fine sand. They are molded under mechanical pressure and hardened under steam pressure.

PART B - TYPES OF BRICK BONDS

By varying the ways in which you lay individual bricks in a wall, you can form a variety of patterns or bonds (Figure 3-2, page 3-5). Different bonds use different combinations of stretchers (bricks laid flat with the long face parallel to the wall) and header (brick laid flat, perpendicular to the face of the wall). A course made up entirely of stretchers is called a stretcher course; a course formed entirely of headers is a header course. The different types of bonds are listed below:

- Running Bond. This is the simplest bond. It consists entirely of stretchers.

- Common or American Bond. A common or American bond is a variation of a running bond with a full course of headers at regular intervals.

- Flemish Bond. In a Flemish bond, each course of bricks is made up of alternate stretchers and headers. The headers in alternate courses are centered over the stretchers in the intervening courses.

- English Bond. The English bond is composed of alternating courses of headers and stretchers.

- Stack Bond. In a stack bond, there is no overlapping of the units; all vertical joints are aligned.

- English Cross Bond. This bond is a variation of the English bond and is different only in that the vertical joints between the stretchers in alternate courses do not line up vertically.

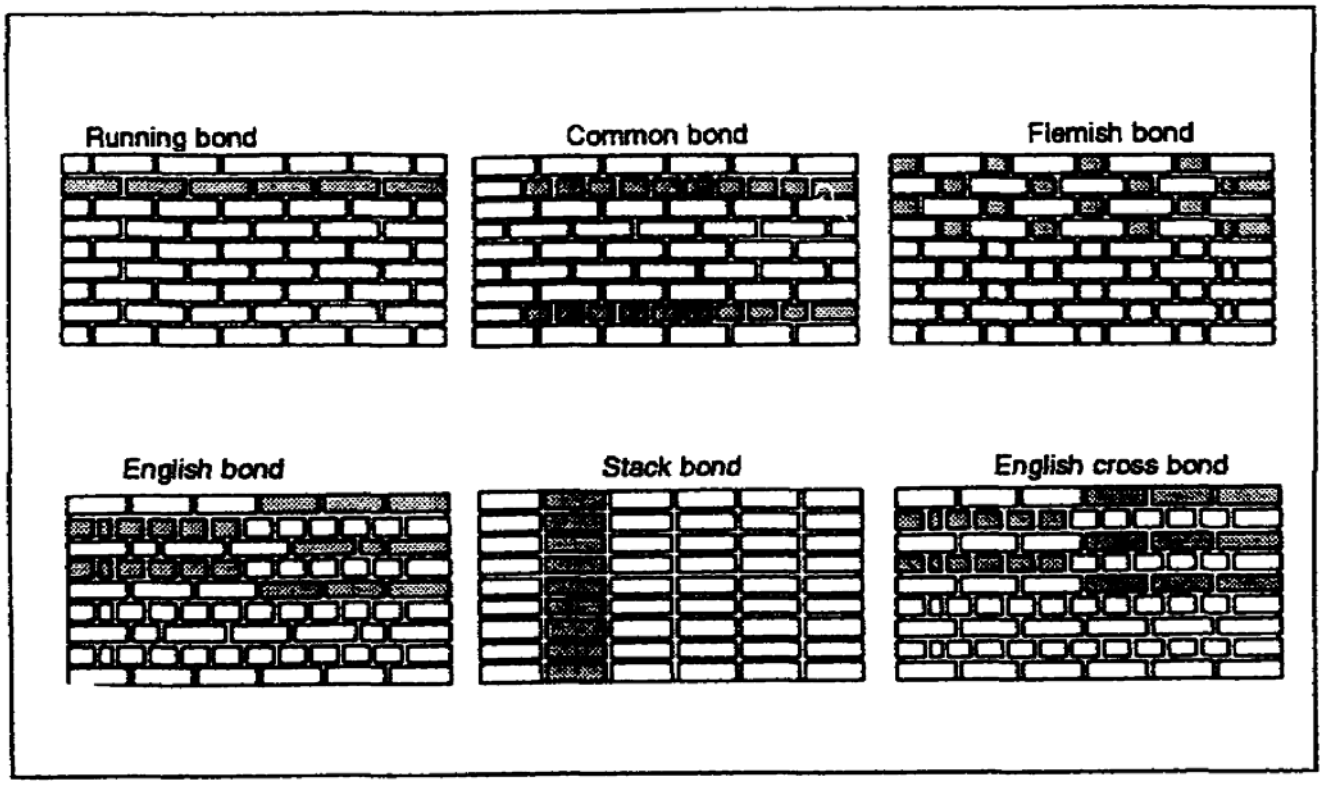

Figure 3-2. Types of brick bonds

PART C - MORTAR JOINTS

The strength of any brick structure depends on-

- The strength of the brick.
- The strength and elasticity of the mortar.
- The workmanship of the bricklayer.
- The uniformity of the bricks.
- The method of laying the bricks.

The strength of mortar is normally greater than that of the brick. The strongest element of a brick wall is mortar. Therefore, the way in which you lay bricks in mortar is very important.

3-4. Using a Trowel. To spread mortar for a bed joint, hold the trowel directly over the centerline of the previous course, tilt the trowel slightly, and drop an equal amount of mortar on four or five bricks along the wall unit (Figure 3-3). Do not make the row too long or the mortar will dry out.

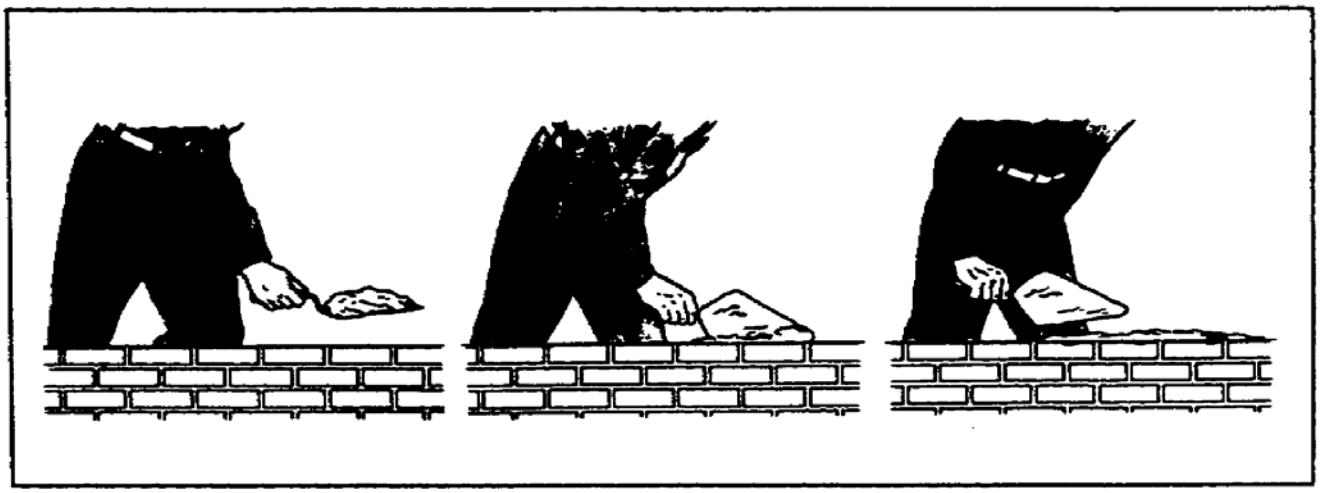

Figure 3-3. Spreading mortar for the bed joint

3-5. Spreading and Furrowing. Use a trowel to spread the mortar about 1 inch thick for the bed joint, and then make a shallow furrow (Figure 3-4).

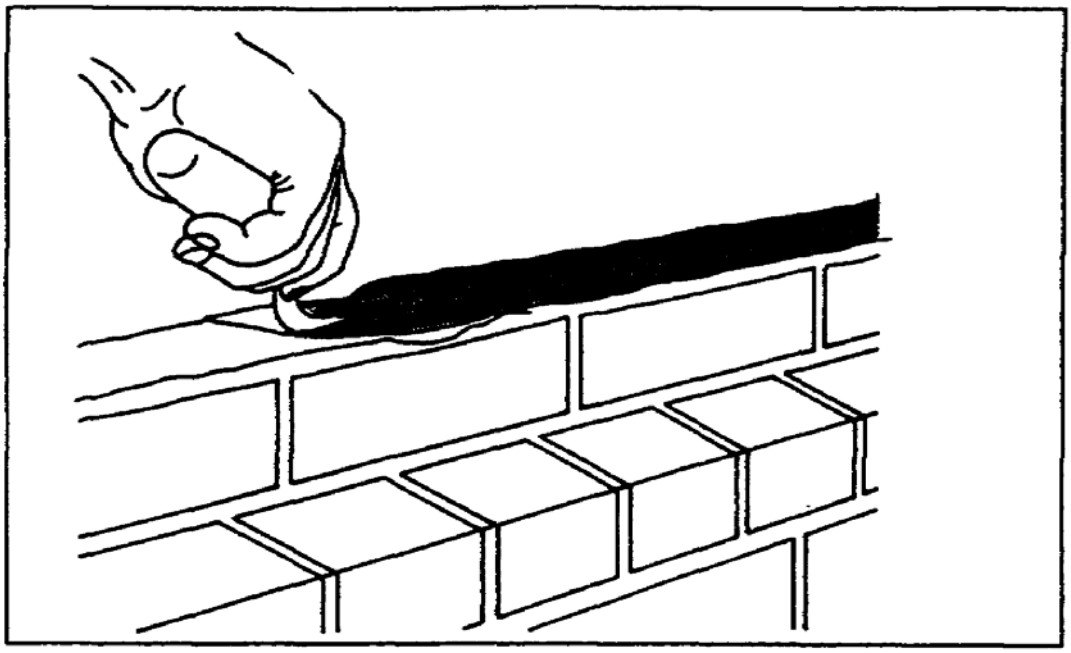

Figure 3-4. Furrowing the bed joint

If the furrow is too deep there will be a gap between the mortar and the brick. This produces a poor bond and will reduce the resistance of the wall to water penetration (Figure 3-5).

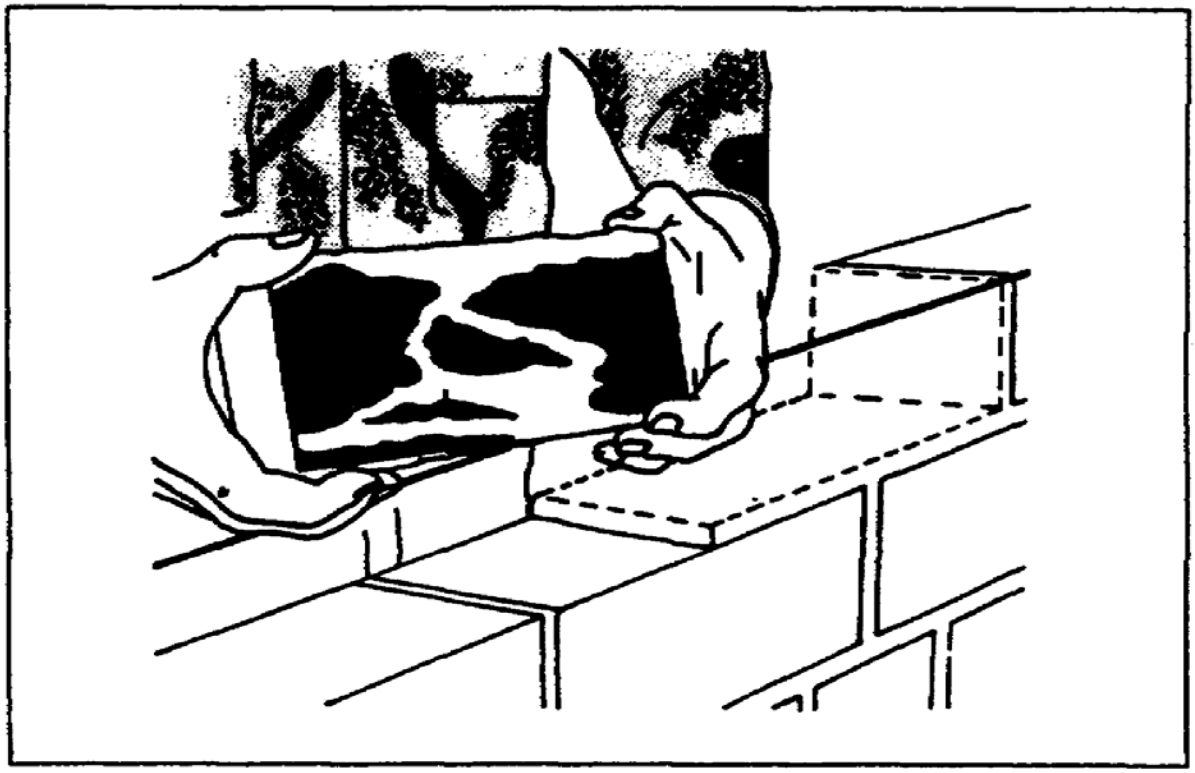

Figure 3-5. Poorly bonded brick

3-6. Laying Head Joints. When laying stretcher courses, you will bond the heads of the bricks together to form a head joint.

a. Buttering a Brick. Figure 3-6 shows the proper way to butter a brick for a head joint. Place as much mortar as will stick on the end of the brick.

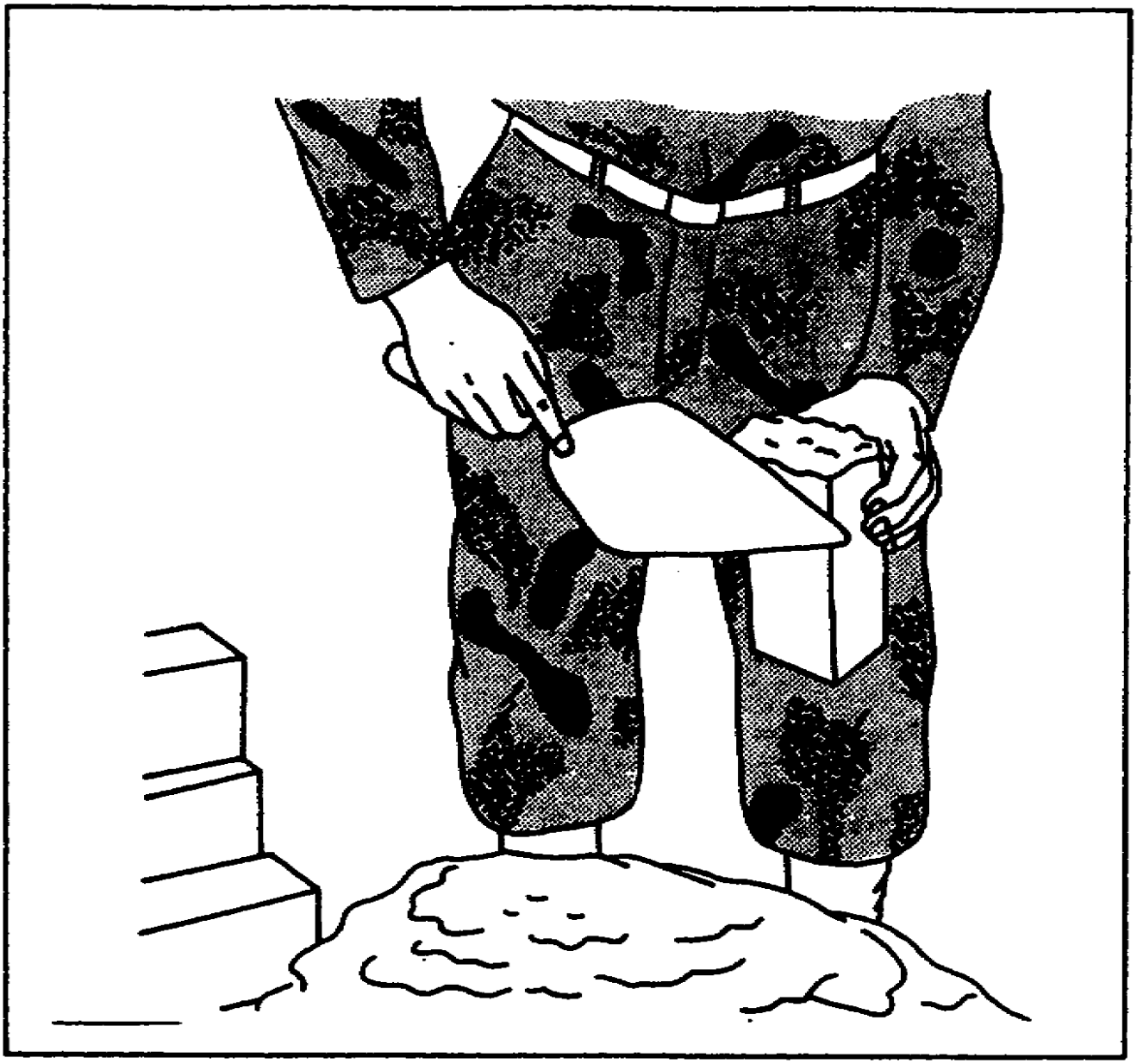

Figure 3-6. Buttering a brick for the head joint

b. Placing a Brick. Push the brick into place so that excess mortar squeezes out at the head joint and at the sides of the wall (Figure 3-7).

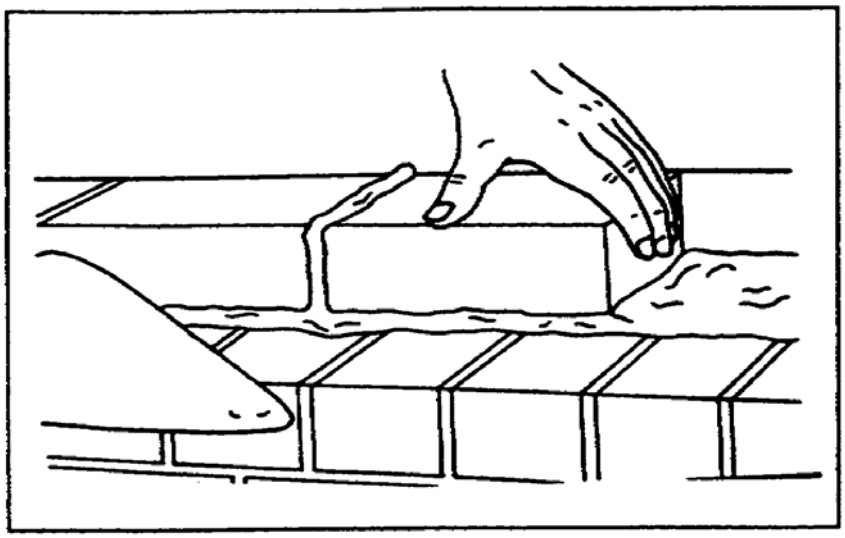

Figure 3-7. Placing a brick in the head joint

3-7. Laying Cross Joints. Cross joints are the joints formed by the long face of the brick when laying header courses. They are laid in the same way you lay the header joints. Spread the mortar for the bed joints several bricks in advance, butter the face of the brick, and push it into position (Figure 3-8). Cross joint must be completely filled with mortar.

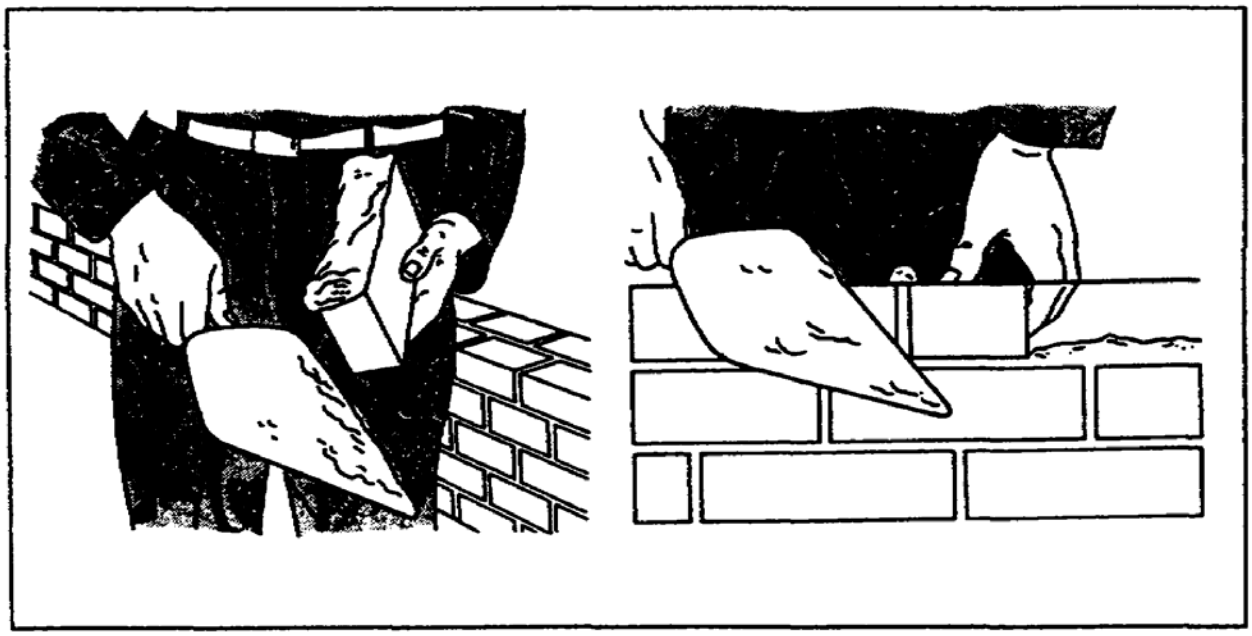

Figure 3-8. Making cross joints in the header courses

3-8. Laying Closure Joints. You must butter both sides of the wall opening and the closure brick itself to ensure a well-filled joint (Figure 3-9). Lay the closure joints in both the header and stretcher the same way.

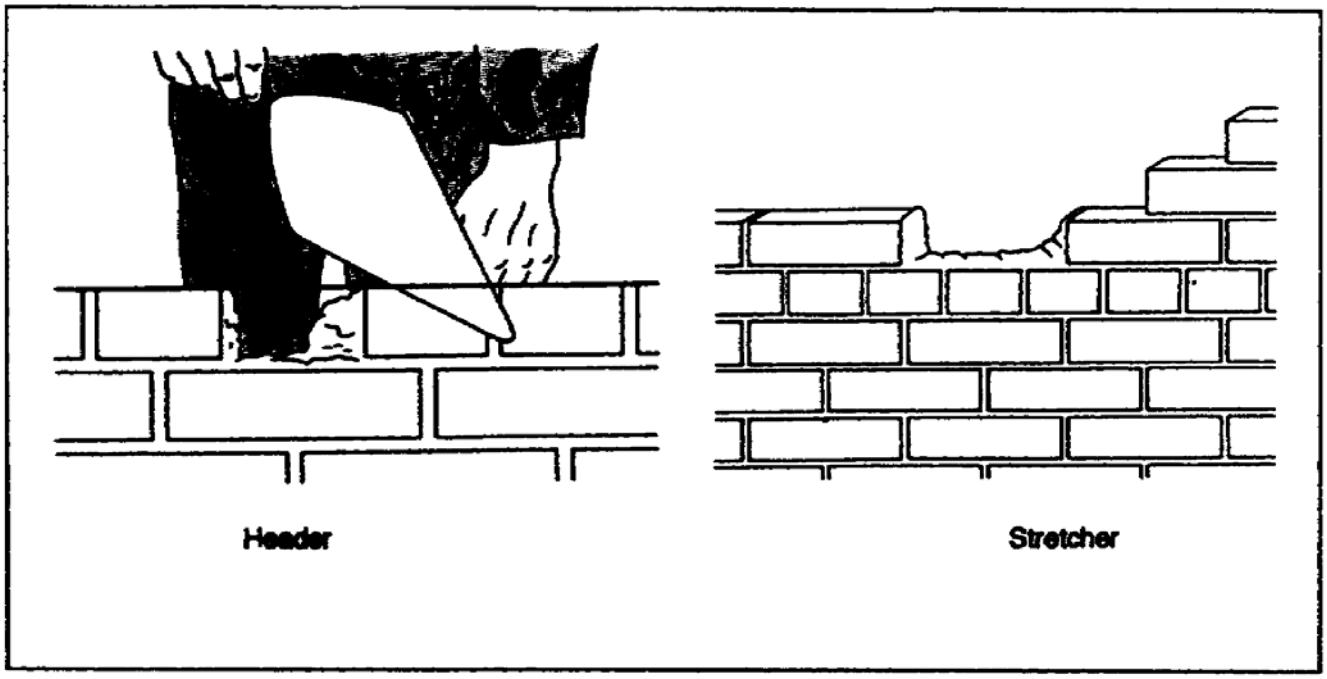

Figure 3-9. Buttered openings for header and stretcher courses

a. Header Closure. Figure 3-10 shows the proper way to butter and place a closure brick in a header closure. After buttering the opening, put as much mortar as will stick on both faces of the header and push it into place.

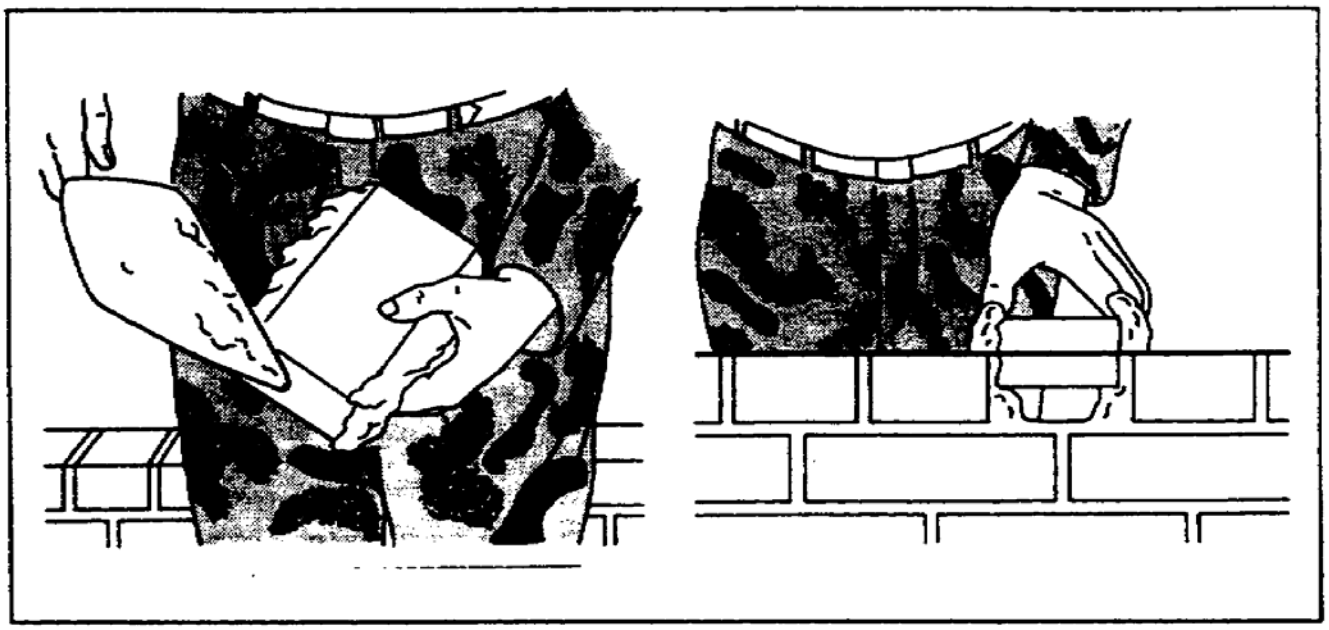

Figure 3-10. Buttering and placing the closure brick in the header course

b. Stretcher Closure. The technique for buttering and placing the closure brick in a stretcher course is shown in Figure 3-11, page 3-12.

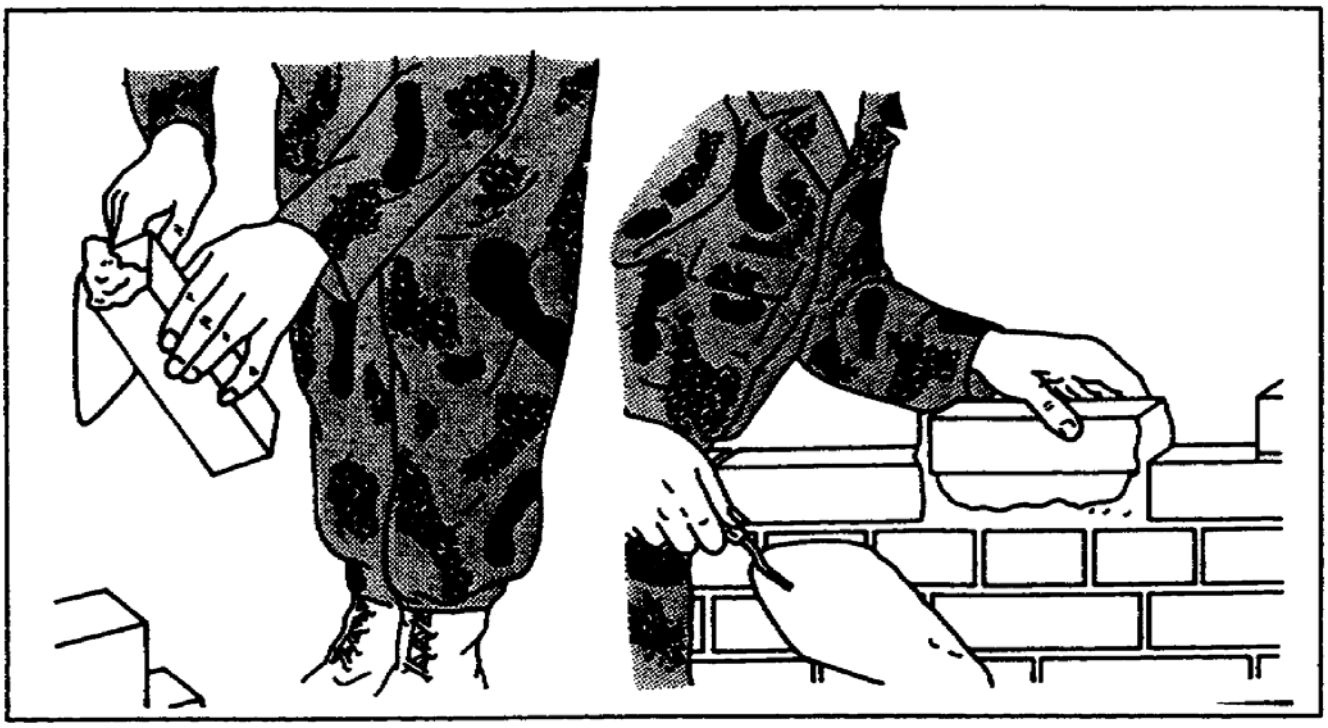

Figure 3-11. Buttering and placing the closure brick in the stretcher course

3-9. Removing Excess Mortar. The excess mortar should be cut off after each brick is in place and used for the next joint. Surplus mortar should be placed back on the mortar bond for retempering, if necessary.

PART D - FINISHING THE JOINTS

When joints are cut flush with the brick and not finished, cracks appear between the brick and the mortar (Figure 3-12). Joints must be finished to make them weathertight.

3-10. Types of Joints. In every case, the mortar joint should be finished before the mortar has hardened.

a. Concave Joint. A concave joint provides the best protection from the weather. A S-shaped jointer is used to press the mortar tight against both of the bricks and finish the joint.

b. Flush Joint. Flush joints are used in interior walls that have little exposure to moisture. This joint is made by holding the trowel almost parallel to the face of the wall while drawing its point along the wall.

c. Weather Joint. This type of joint is formed by pushing downward on the mortar with the top edge of the trowel. Weather joints are good for walls that are exposed to lots of rain.

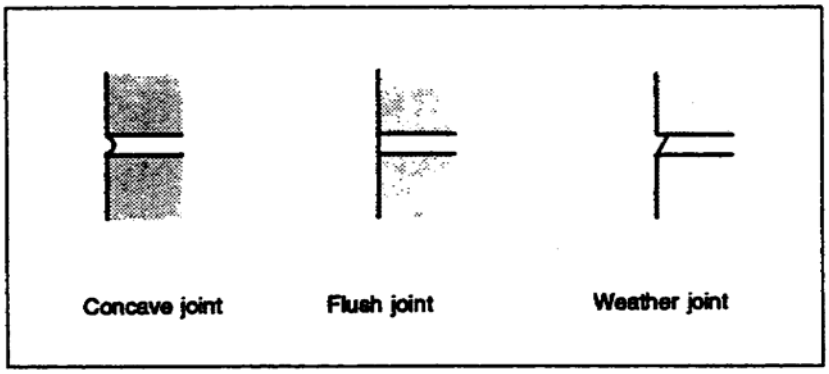

Figure 3-12. Joints

PART E - CUTTING THE BRICKS

Bricks are often cut into different shapes to fill in spaces at corners and other places where a full brick will not fit (Figure 3-13).

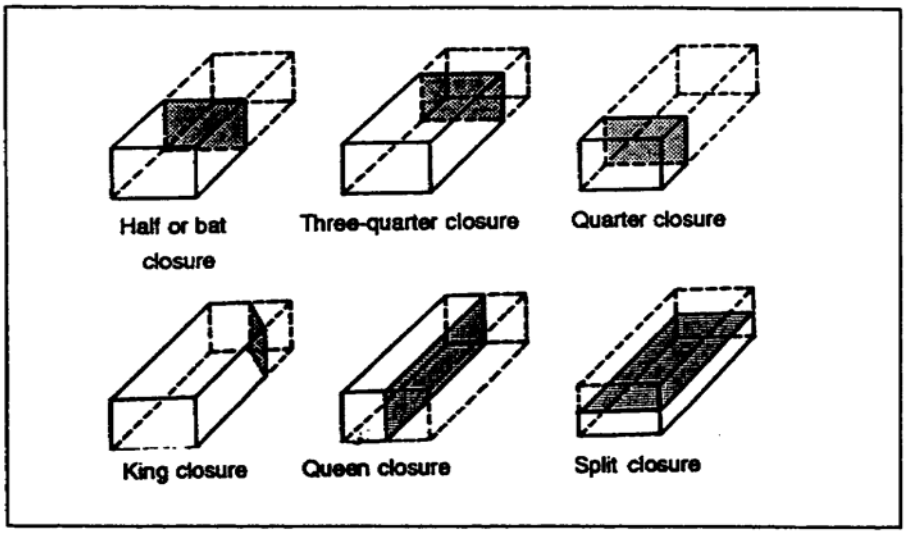

Figure 3-13. Common shapes of cut brick

3-11. Cutting with a Bolster. If you must cut a brick to an exact line, use the bolster. When you use this tool, the straight side of the cutting edge should face both the part of the brick to be saved and the bricklayer. After you make a cutting line, one blow of the hammer should be enough to break the brick (Figure 3-14).

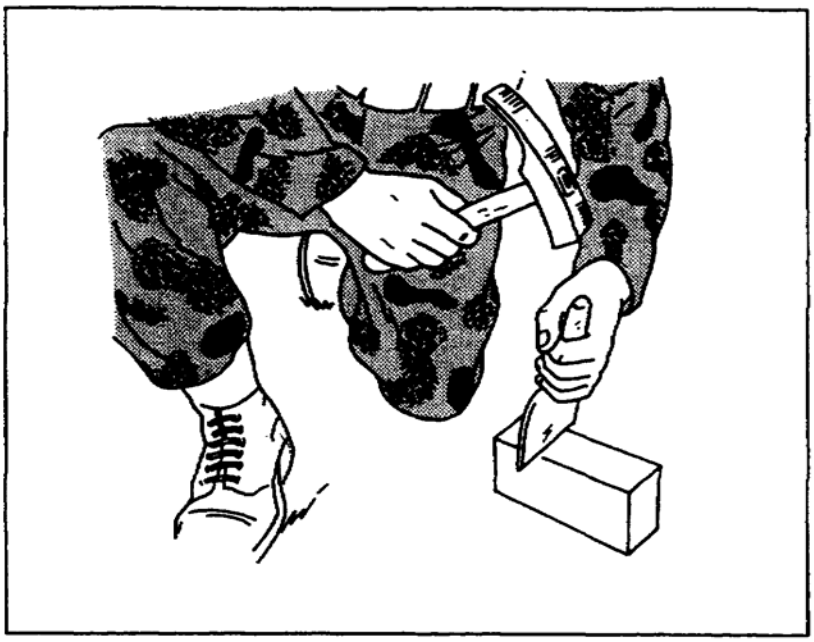

Figure 3-14. Cutting a brick with a bolster

3-12. Cutting with a Hammer. When you are cutting with a hammer, the first step is to make a cutting line around the brick using blows from the head of the brick hammer. When the line is complete, a sharp blow to one side of the cutting line will split the brick at the line. Trim rough places off by using the blade of the hammer (Figure 3-15, page 3-16). Ensure proper eye protection is used during this procedure.

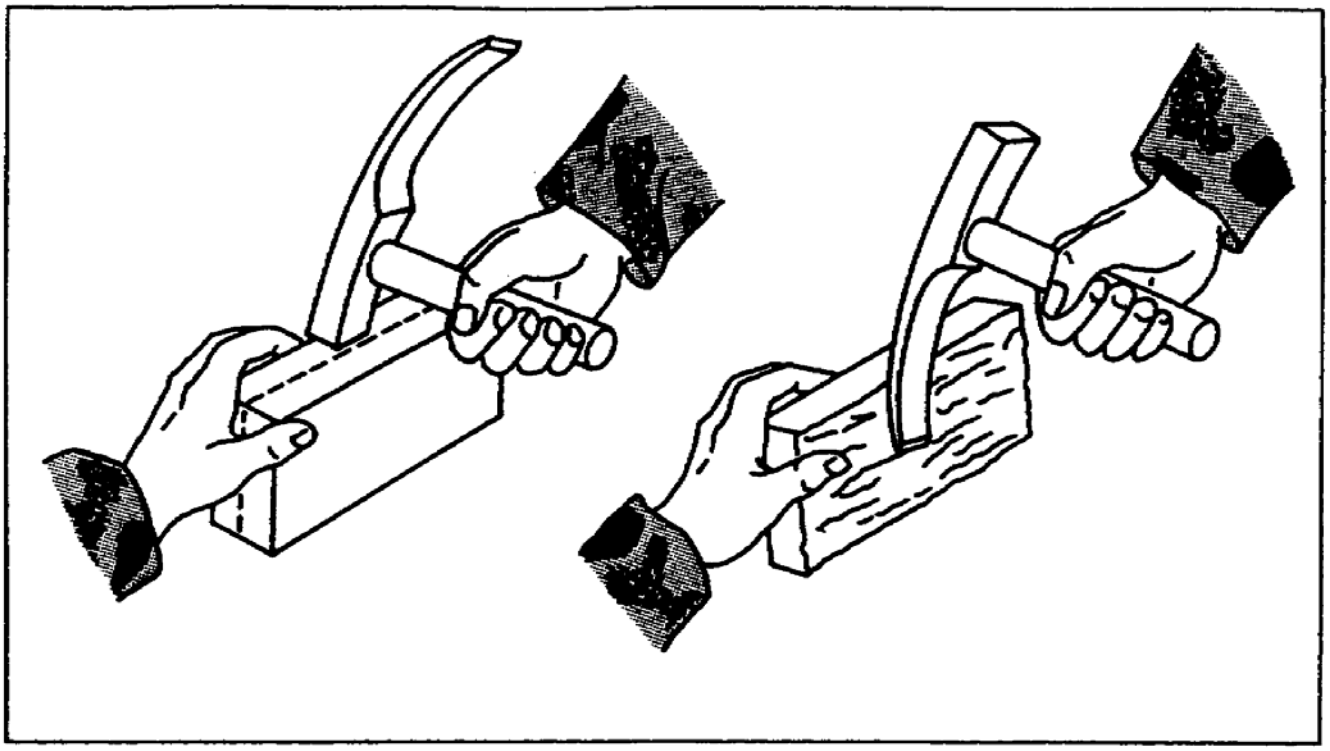

Figure 3-15. Cutting and trimming with a hammer

PART F - LAYING A COMMON BOND BRICK WALL

To build a wall of a given length, adjust the width of the head joint so that a particular number of bricks will equal the given length. Before laying a brick wall, determine the number of courses you will need. Tables 3-1 through 3-3, pages 3-18 through 3-20, gives the number of courses required for a given wall height using standard bricks and different joint widths.

Table 3-1. Height of courses using 2 1/4-inch brick, 3/8-inch mortar joint

Courses	Height	Courses	Height	Courses	Height	Courses	Height	Courses	Height
1	0' 2 5/8"	21	4' 7 1/8"	41	8' 11 5/8"	61	13' 4 1/8"	81	17' 8 5/8"
2	0' 5 1/4"	22	4' 9 3/4"	42	9' 2 1/4"	62	13' 6 3/4"	82	17' 11 1/4"
3	0' 7 7/8"	23	5' 0 3/8"	43	9' 4 7/8"	63	13' 9 3/8"	83	18' 1 7/8"
4	0' 10 1/2"	24	5' 3"	44	9' 7 1/2"	64	14' 0"	84	18' 4 1/2"
5	1' 1 1/8"	25	5' 5 3/8"	45	9' 10 1/8"	65	14' 2 5/8"	85	18' 7 1/8"
6	1' 3 3/4"	26	5' 8 1/4"	46	10' 0 3/4"	66	14' 5 1/4"	86	18' 9 3/4"
7	1' 6 3/8"	27	5' 10 7/8"	47	10' 3 3/8"	67	14' 7 7/8"	87	19' 0 3/8"
8	1' 9"	28	6' 1 1/2"	48	10' 6"	68	14' 101/2"	88	19' 3"
9	1' 11 5/8"	29	6' 4 1/8"	49	10' 8 5/8"	69	15' 1 1/8"	89	19' 5 5/8"
10	2' 2 1/4"	30	6' 6 3/4"	50	10' 11 1/4"	70	15' 3 3/4"	90	19' 8 1/4"
11	2' 4 7/8"	31	6' 9 3/8"	51	11' 1 7/8"	71	15' 6 3/8"	91	19' 107/8"
12	2' 7 1/2"	32	7' 0"	52	11' 4 1/2"	72	15' 9"	92	20' 1 1/2"
13	2' 10 1/8"	33	7' 2 5/8"	53	11' 7 1/8"	73	15' 115/8"	93	20' 4 1/8"
14	3' 0 3/4"	34	7' 5 1/4"	54	11' 9 3/4"	74	16' 2 1/4"	94	20' 6 3/4"
15	3' 3 3/8"	35	7' 7 7/8"	55	12' 0 3/8"	75	16' 4 7/8"	95	20' 9 3/8"
16	3' 6"	36	7' 10 1/2"	56	12' 3"	76	16' 7 1/2"	96	21' 0"
17	3' 8 5/8"	37	8' 1 1/8"	57	12' 5 5/8"	77	16' 10 1/8"	97	21' 25/8"
18	3' 11 1/4"	38	8' 3 3/4"	58	12' 8 1/4"	78	17' 0 3/4"	98	21' 5 1/4"
19	4' 1 7/8"	39	8' 6 3/8"	59	12' 10 7/8"	79	17' 3 3/8"	99'	21' 7 7/8"
20	4' 4 1/2"	40	8' 9"	60	13' 1 1/2"	80	17' 6"	100	21' 10 1/2"

Table 3-2. Height of course using 2 1/4-inch brick, 1/2-inch mortar joint

Courses	Height	Courses	Height	Courses	Height	Courses	Height	Courses	Height
1	0' 2 3/4"	21	4' 9 3/4"	41	9' 4 3/4"	61	13' 11 3/4"	81	18' 6 3/4"
2	0' 5 1/2"	22	5' 0 1/2"	42	9' 7 1/2"	62	14' 2 1/2"	82	18' 9 1/2"
3	0' 8 1/4"	23	5' 3 1/4"	43	9' 10 1/4"	63	14' 5 1/4"	83	19' 0 1/4"
4	0' 11"	24	5' 6"	44	10' 1"	64	14' 8"	84	19' 3"
5	1' 1 3/4"	25	5' 8 3/4"	45	10' 3 3/4"	65	14' 10 3/4"	85	19' 5 3/4"
6	1' 4 1/2"	26	5' 11 1/2"	46	10' 6 1/2"	66	15' 1 1/2"	86	19' 8 1/2"
7	1' 7 1/4"	27	6' 2 1/4"	47	10' 9 1/4"	67	15' 4 1/4"	87	19' 11 1/4"
8	1' 10"	28	6' 5"	48	11' 0"	68	15' 7"	88	20' 2"
9	2' 0 3/4"	29	6' 7 3/4"	49	11' 2 3/4"	69	15' 9 3/4"	89	20' 4 3/4"
10	2' 3 1/2"	30	6' 10 1/2"	50	11' 5 1/2"	70	16' 0 1/2"	90	20' 7 1/2"
11	2' 6 1/4"	31	7' 1 1/4"	51	11' 8 1/4"	71	16' 3 1/4"	91	20' 10 1/4"
12	2' 9"	32	7' 4"	52	11' 11"	72	16' 6"	92	21' 1"
13	2' 11 3/4"	33	7' 6 3/4"	53	12' 1 3/4"	73	16' 8 3/4"	93	21' 3 3/4"
14	3' 2 1/2"	34	7' 9 1/2"	54	12' 4 1/2"	74	16' 11 1/2"	94	21' 6 1/2"
15	3' 5 1/4"	35	8' 0 1/4"	55	12' 7 1/4"	75	17' 2 1/4"	95	21' 9 1/4"
16	3' 8"	36	8' 3"	56	12' 10"	76	17' 5"	96	22' 0"
17	3' 10 3/4"	37	8' 5 3/4"	57	13' 0 3/4"	77	17' 7 3/4"	97	22' 2 3/4"
18	4' 1 1/2"	38	8' 8 1/2"	58	13' 3 1/2"	78	17' 10 1/2"	98	22' 5 1/2"
19	4' 4 1/4"	39	8' 11 1/4"	59	13' 6 1/4"	79	18' 1 1/4"	99	22' 8 1/4"
20	4' 7"	40	9' 2"	60	13' 9"	80	18' 4"	100	22' 11"

Table 3-3. Height of courses using 2 1/4-inch brick, 5/8-inch mortar joint

Courses	Height	Courses	Height	Courses	Height	Courses	Height	Courses	Height
1	0' 2 7/8"	21	5' 0 3/8"	41	9' 9 7/8"	61	14' 7 3/8"	81	19' 4 7/8"
2	0' 5 3/4"	22	5' 3 1/4"	42	10' 0 3/4"	62	14' 10 1/4"	82	19' 7 3/4"
3	0' 8 5/8"	23	5' 6 1/8"	43	10' 3 5/8"	63	15' 1 1/8"	83	19' 10 5/8"
4	0' 11 1/2"	24	5' 9"	44	10' 6 1/2"	64	15' 4"	84	20' 1 1/2"
5	1' 2 3/8"	25	5' 11 7/8"	45	10' 9 3/8"	65	15' 6 7/8"	85	20' 4 3/8"
6	1' 5 1/4"	26	6' 2 3/4"	46	11' 0 1/4"	66	15' 9 3/4"	86	20' 7 1/4"
7	1' 8 1/8"	27	6' 5 5/8"	47	11' 3 1/8"	67	16' 0 5/8"	87	20' 10 1/8"
8	1' 11"	28	6' 8 1/2"	48	11' 6"	68	16' 3 1/2"	88	21' 1"
9	2' 1 7/8"	29	6' 11 3/8"	49	11' 8 7/8"	69	16' 6 3/8"	89	21' 3 7/8"
10	2' 4 3/4"	30	7' 2 1/4"	50	11' 11 3/4"	70	16' 9 1/4"	90	21' 6 3/4"
11	2' 7 5/8"	31	7' 5 1/8"	51	12' 2 5/8"	71	17' 0 1/8"	91	21' 9 5/8"
12	2' 10 1/2"	32	7' 8"	52	12' 5 1/2"	72	17' 3"	92	22' 0 1/2"
13	3' 1 3/8"	33	7' 10 7/8"	53	12' 8 3/8"	73	17' 5 7/8"	93	22' 3 3/8"
14	3' 4 1/4"	34	8' 1 3/4"	54	12' 11 1/4"	74	17' 8 3/4"	94	22' 6 1/4"
15	3' 7 1/8"	35	8' 4 5/8"	55	13' 2 1/8"	75	17' 11 5/8"	95	22' 9 1/8"
16	3' 10"	36	8' 7 1/2"	56	13' 5"	76	18' 2 1/2"	96	23' 0"
17	4' 0 7/8"	37	8' 10 3/8"	57	13' 7 1/8"	77	18' 5 3/8"	97	23' 2 7/8"
18	4' 3 3/4"	38	9' 1 1/4"	58	13' 10 3/4"	78	18' 8 1/4"	98	23' 5 3/4"
19	4' 6 5/8"	39	9' 4 1/8"	59	14' 1 5/8"	79	18' 11 1/8"	99	23' 8 5/8"
20	4' 9 1/2"	40	9' 7"	60	14' 4 1/2"	80	19' 2"	100	23' 11 1/2"

3-13. Planning the layout. To plan the layout of a wall, lay both a stretcher and a header course on the foundation without mortar. Leave enough distance between each brick for the mortar joints. This will help you determine the number of bricks in one course and the amount of cutting to be done (Figure 3-16).

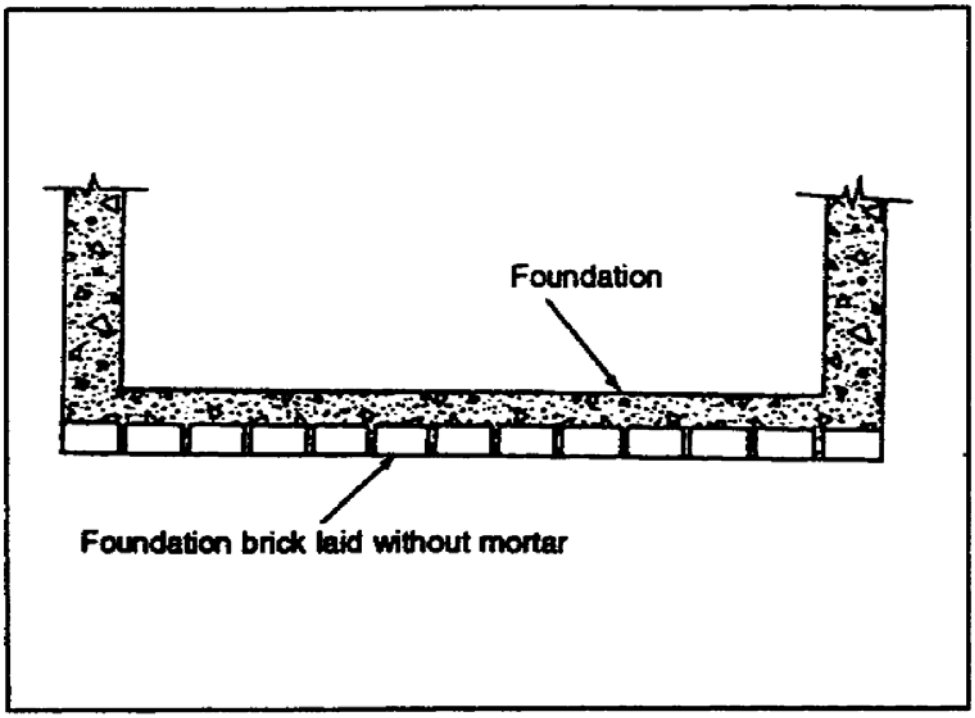

Figure 3-16. Determining the number of bricks in a stretcher course

3-14. Laying the Leads. Laying the leads means erecting the corner first. The corner leads are used as guides in laying the remainder of the wall. The corner leads are laid six or seven courses above the first course (Figure 3-17).

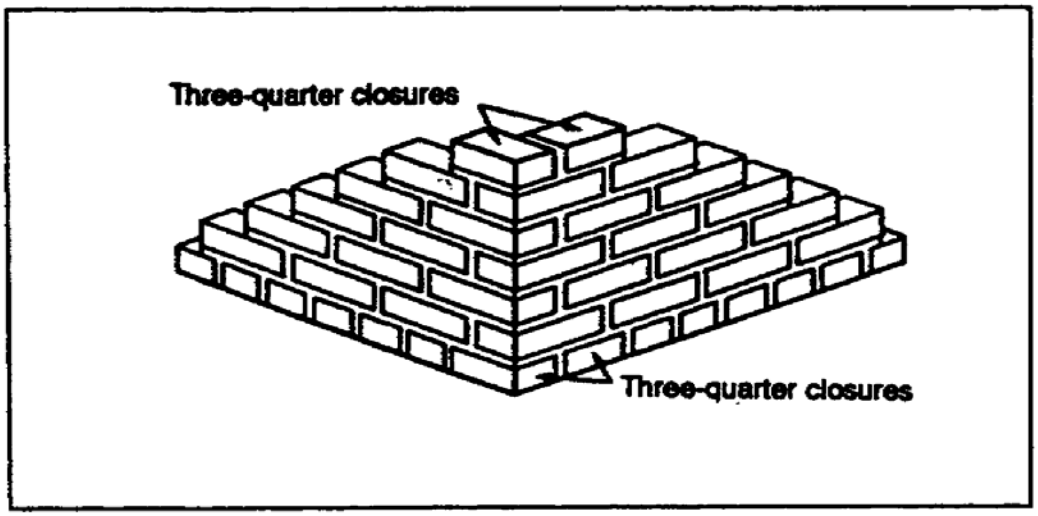

Figure 3-17. Corner lead for an 8-inch common bond brick wall

3-15. Laying the First Course (Header Course). Below are the steps in laying the header course for a corner lead.

a. First Step. Lay a l-inch bed of mortar on foundation as shown in Figure 3-18.

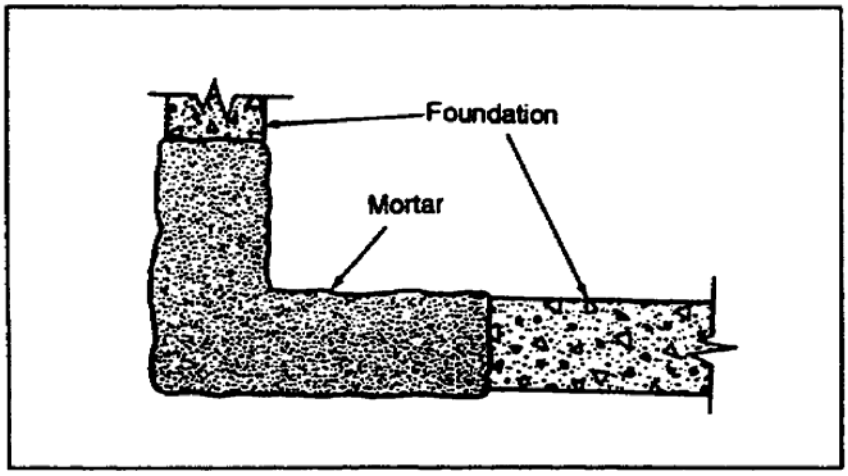

Figure 3-18. Spreading mortar on the foundation

b. Second Step. As shown in Figure 3-19, cut and lay two three-quarter closure bricks. Press the closure brick marked A down into the mortar bed until it makes a bed joint 1/2 inch thick. Next spread the mortar on the end of the closure brick marked B and position it to form a 1/2-inch- thick head joint with the closure brick marked A. Check the level of the closure bricks by using a level at the points indicated by the heavy dotted lines. The edges of the closures bricks must be even with the outside face of the foundation.

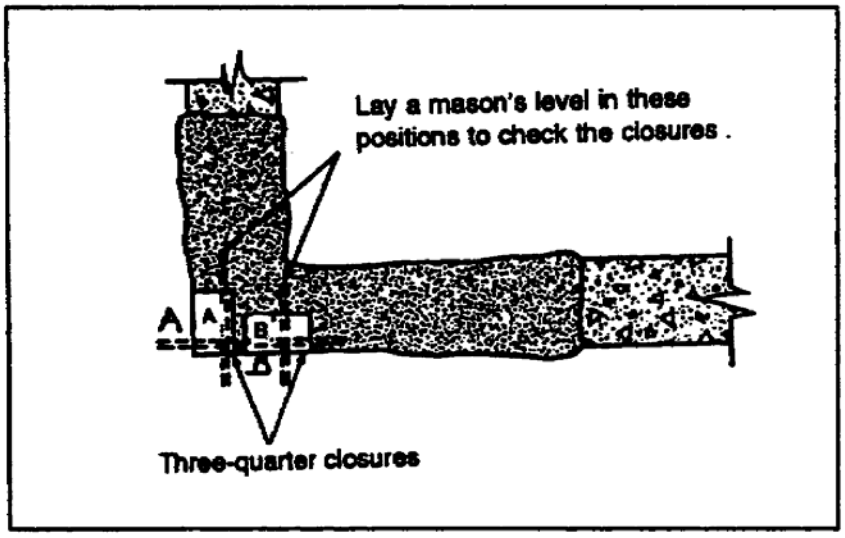

Figure 3-19. Laying three-quarter closure bricks

c. Third Step. Lay the header bricks and the quarter closure bricks. Spread mortar on the side of the brick marked C. Lay it as shown in Figure 3-20, and level it. The outside end of the brick must be even with the outside face of the foundation. Lay the brick marked D, check its position, and level it. When the brick marked D is in position, cut the next two quarter closure bricks marked E and F and place them in position, making sure they are level.

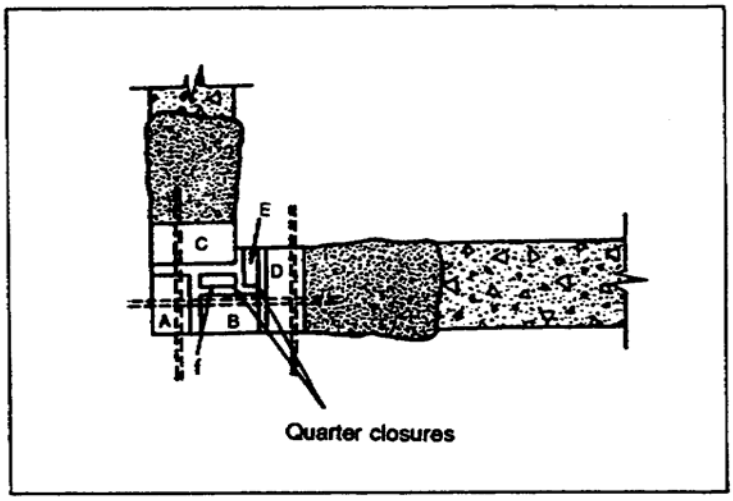

Figure 3-20. Laying the quarter closure bricks and header bricks

d. Fourth Step. Lay the remaining header bricks. Butter the brick marked G and push it into position (Figure 3-21, page 3-24). Butter and lay the bricks H I, J, and K in the same manner. Butter and lay the remaining bricks marked , N, O, and P in the bottom course. You must lay 12 header bricks in the first course of the corner lead-6 bricks on each side of the three-quarter closure marked A and B. Be sure to level each brick as it is laid.

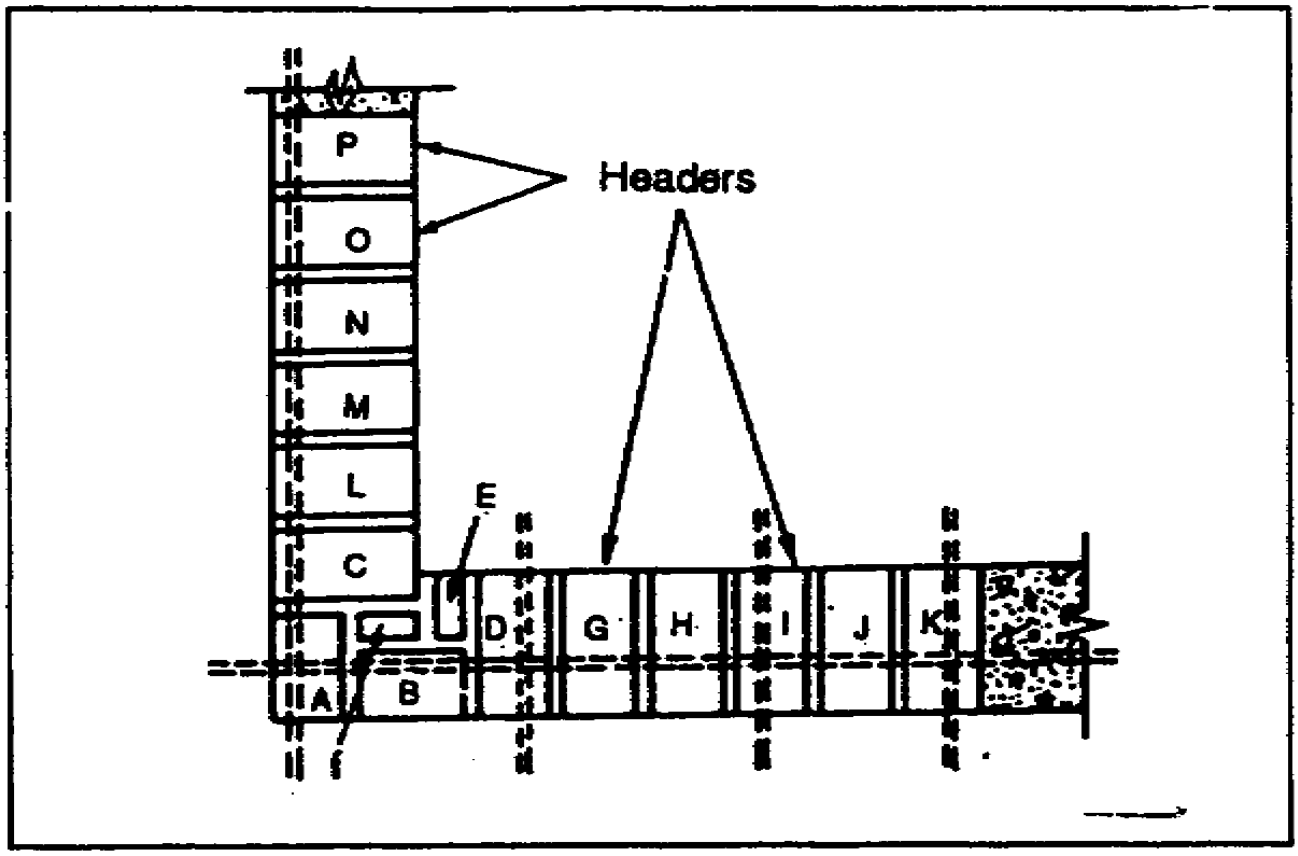

Figure 3-21. Laying the remaining header bricks

3-16. Laying the Second Course (Stretcher Course). You are now ready to lay a stretcher course at the corners.

3-17. Spreading Mortar. Spread a 1-inch bed of mortar on the first course and make a shallow furrow in it (Figure 3-22).

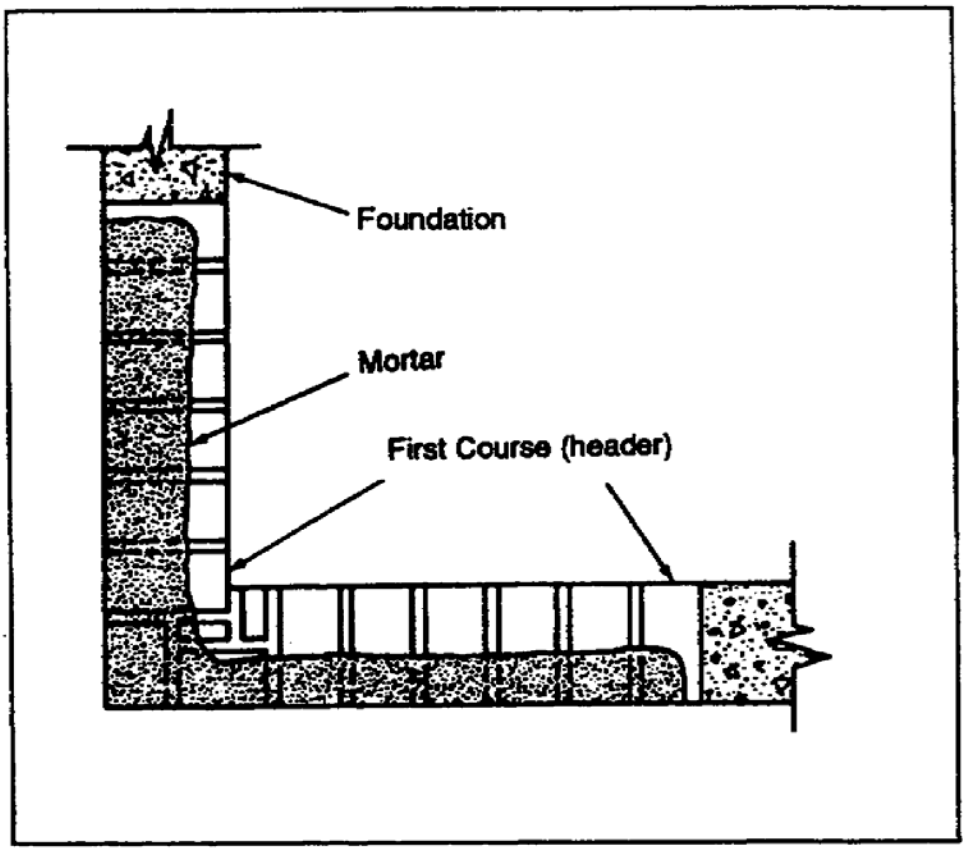

Figure 3-22. Spreading mortar for the stretcher course

3-18. Laying bricks for the stretchers course. To lay the stretcher course, push the brick marked A into the mortar until it makes a joint 1/2 inch thick. Now, butter the bricks marked B, C, D, E, F, and G and place them in the mortar, in alphabetical order (Figure 3-23).

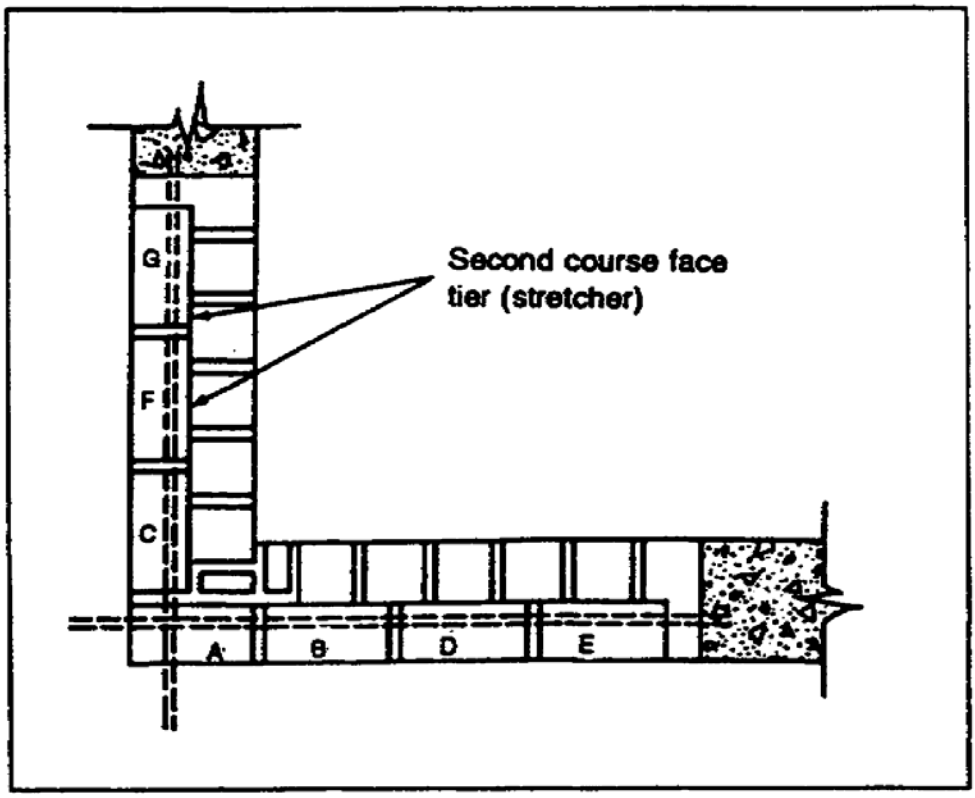

Figure 3-23. Laying the stretcher course

3-19. Leveling and Plumbing. Use the leads as a guide to lay the portion of the wall between them, and continually check their level. After the first few courses, the lead is plumbed. To avoid weakening the mortar bond do not move a brick once it has been placed in the mortar (Figure 3-24).

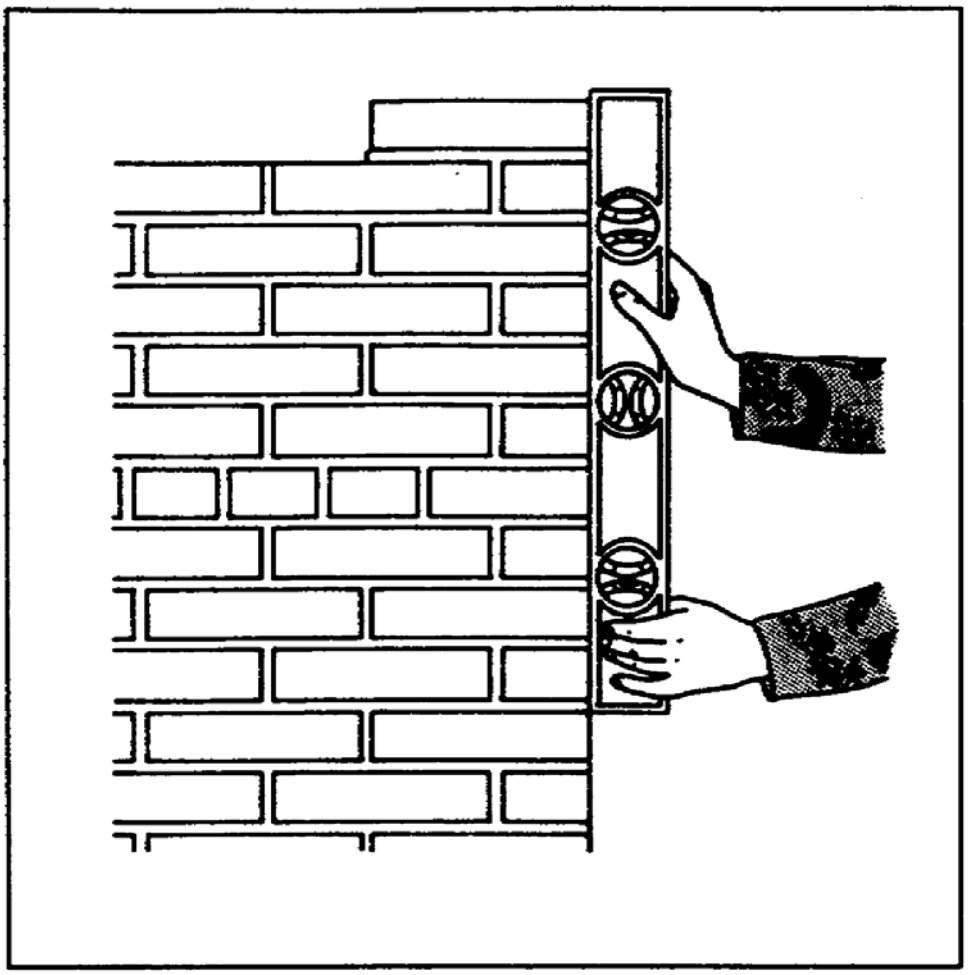

Figure 3-24. Plumbing a corner

3-20. Laying the Opposite Corner. The lead at the opposite corner of the wall is constructed using the same steps you followed above. Because the leads are used as a guide for the rest of the wall, it is essential that you lay corresponding courses in opposite leads on the same level.

3-21. Using a String Line. To lay stretcher courses between the leads, you will need to use a string line.

a. Constructing the Line. Drive the nails into the mortar joint to support the line. Attach the line to the nail in the left-hand lead, pulling it tight. After the line is firm, attach the line to the nail in the right-hand lead (Figure 3-25).

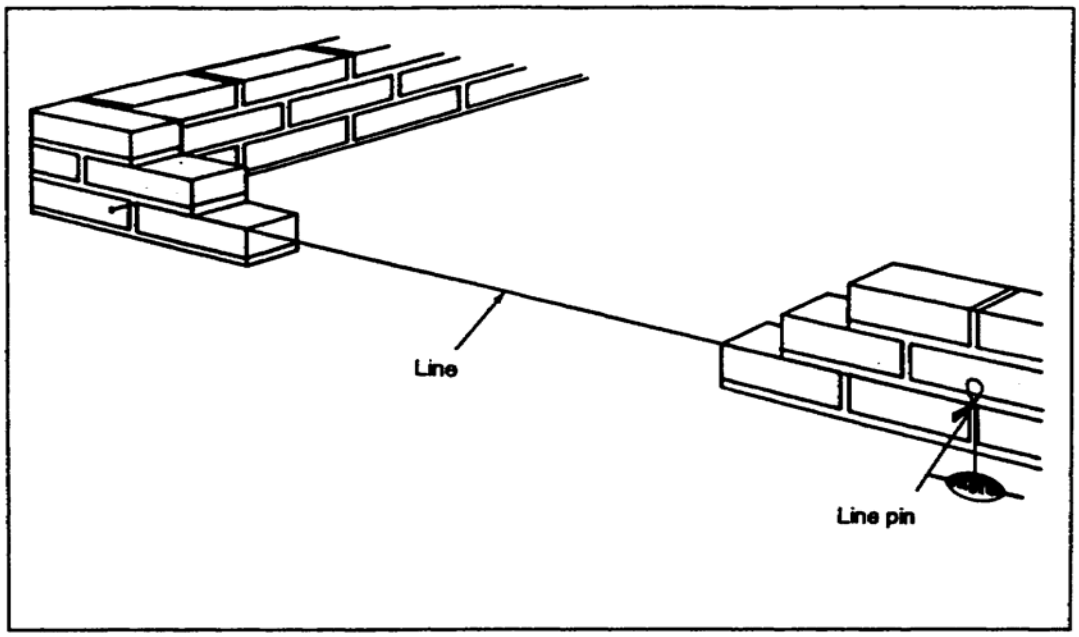

Figure 3-25. Using the string line

b. Laying the First Course. Having the string line in place, lay the first stretcher course between the two corner leads. Push the bricks into position so that their top edges are 1/16 inch behind the line.

c. Laying the Remaining Courses. For the next course, move the string line up to the next mortar joint. Lay the course as before, finishing the face joints before the mortar hardens. The wall should be checked at several points, making sure it is level and plumb.

d. Using a Trig. When a string line is stretched across a long wall, use a trig to prevent it from sagging. A trig is a short piece of line that loops around the string line at its midpoint and fastens the top edge of a previously laid brick in the middle lead. A piece of broken brick rests on top of the trig to hold it in place (Figure 3-26).

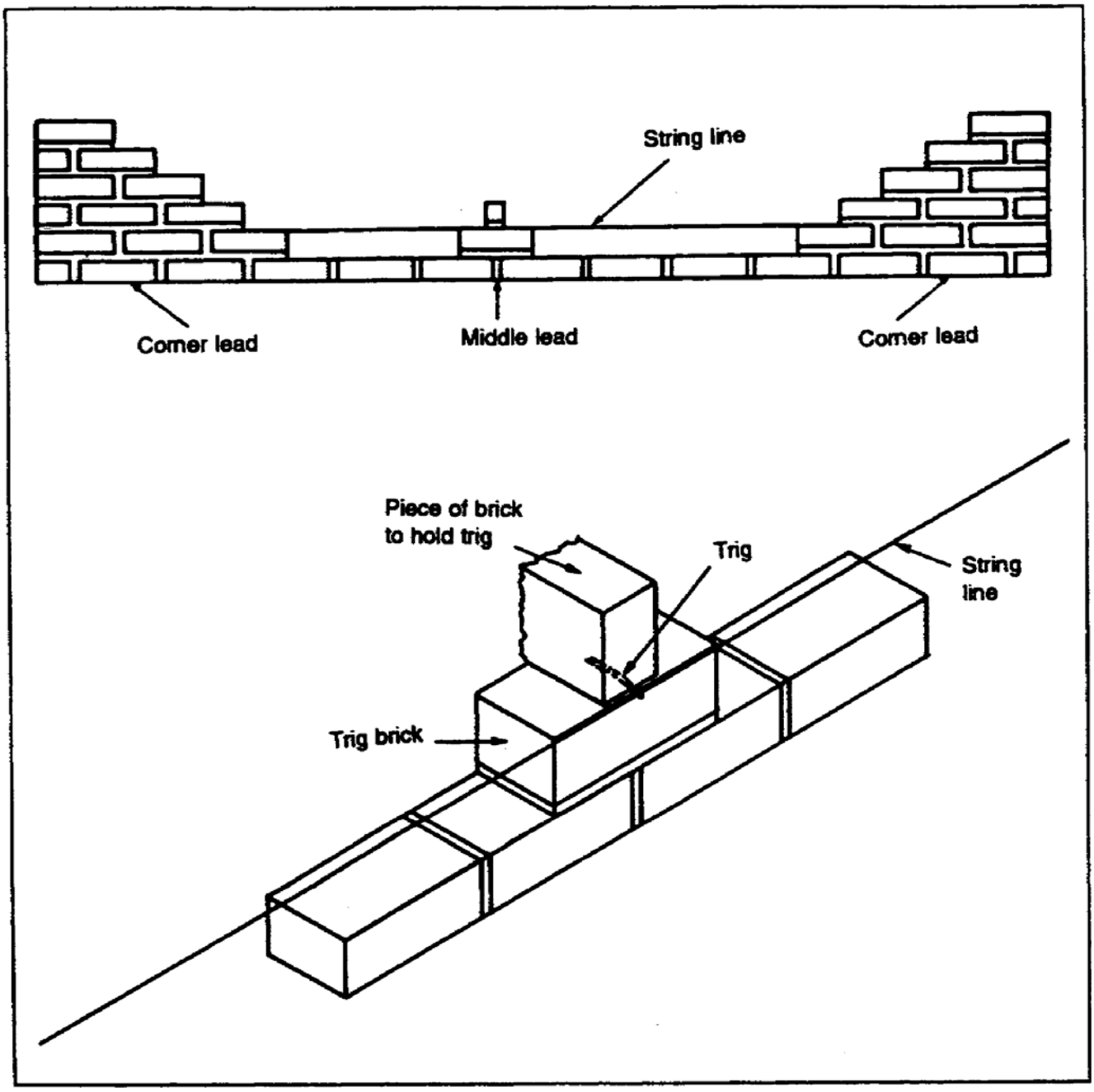

Figure 3-26. Constructing a trig

PART G - WINDOW AND DOOR OPENINGS

As the bricklaying proceeds, you must leave openings for windows and doors in the wall. Determine the distance from the foundation to the bottom of the window sill. The height of the wall to the top of one full course must equal that distance (Figure 3-27). Do not count the tilted rowlock (the row of bricks laid on the edge) as a course; it is part of the sill.

3-22. Window Openings. When you know the distance from the foundation to the bottom of the window sill, you can determine how many courses are required to bring the wall up to that height. For example, if the sill is 4 feet, 4 1/4 inches above the foundation using 1/2-inch mortar joints, you will need to lay 19 courses before you reach the bottom of the sill (Table 3-2, page 3-19).

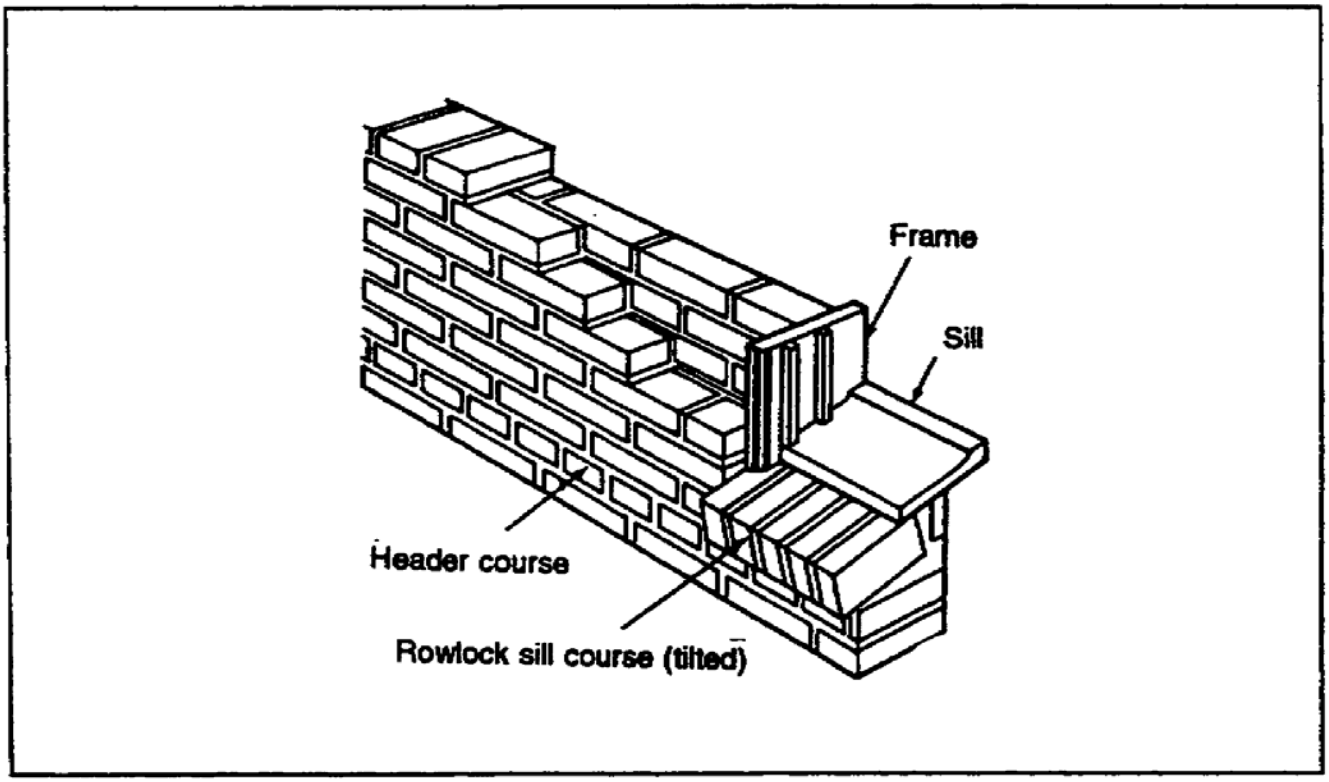

Figure 3-27. Constructing a window opening

3-23. Placing and Bracing the Frame. Place the window frame on the rowlock course as soon as the mortar has set. You must brace the window frame until the brick work has been laid up to about one-third the height of the frame (Figure 3-28).

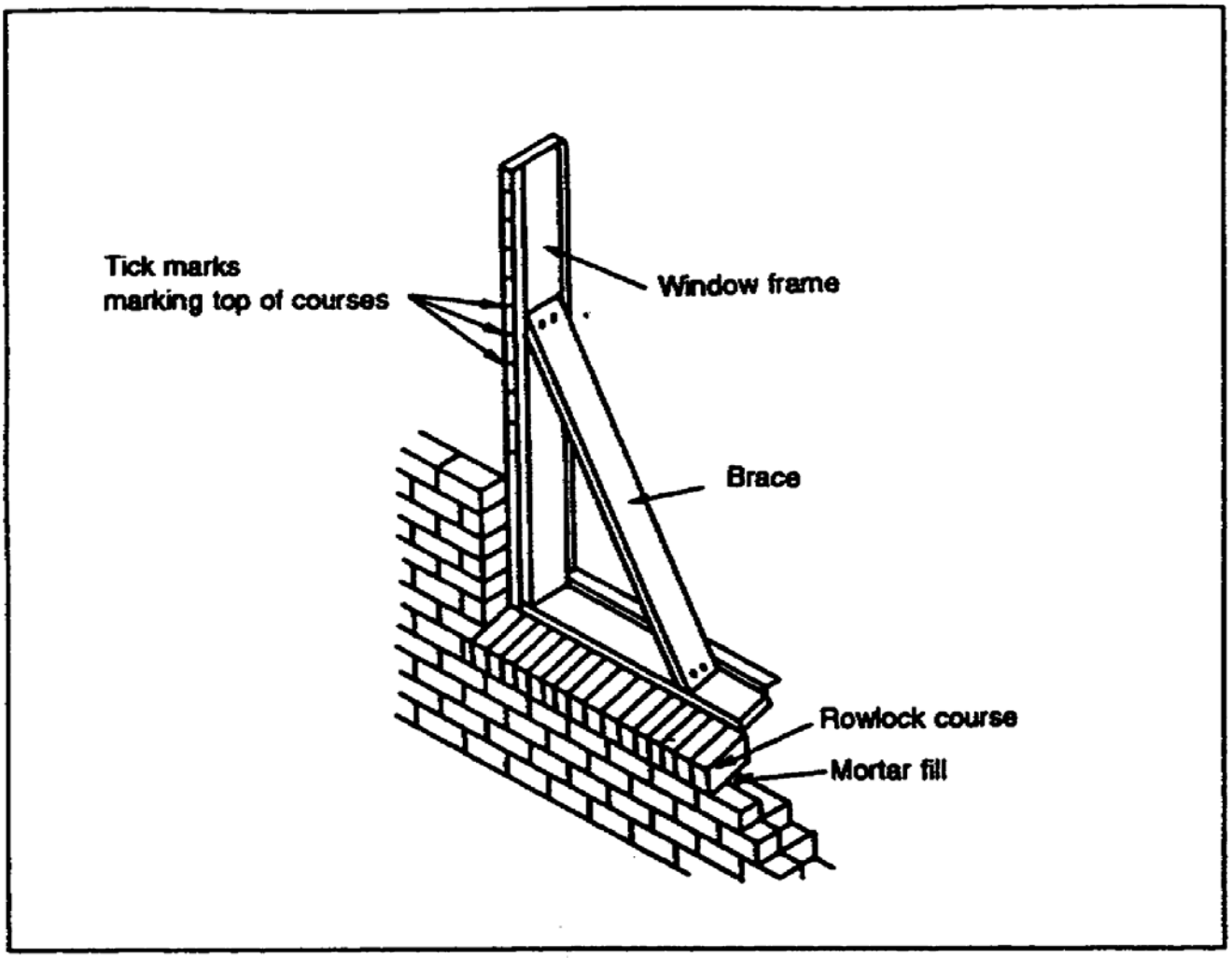

Figure 3-28. Bracing and marking the frame

3-24. Marking the Courses. The remaining bricks in the wall should be laid so that the top of the brick in the course is no more than 1/4 inch above the window frame (Figure 3-29). To do this, use a pencil to mark the top of each course on the window frame itself. If the mark for the top of the last course does not come to the proper level, change the joint thickness you plan to use until it does.

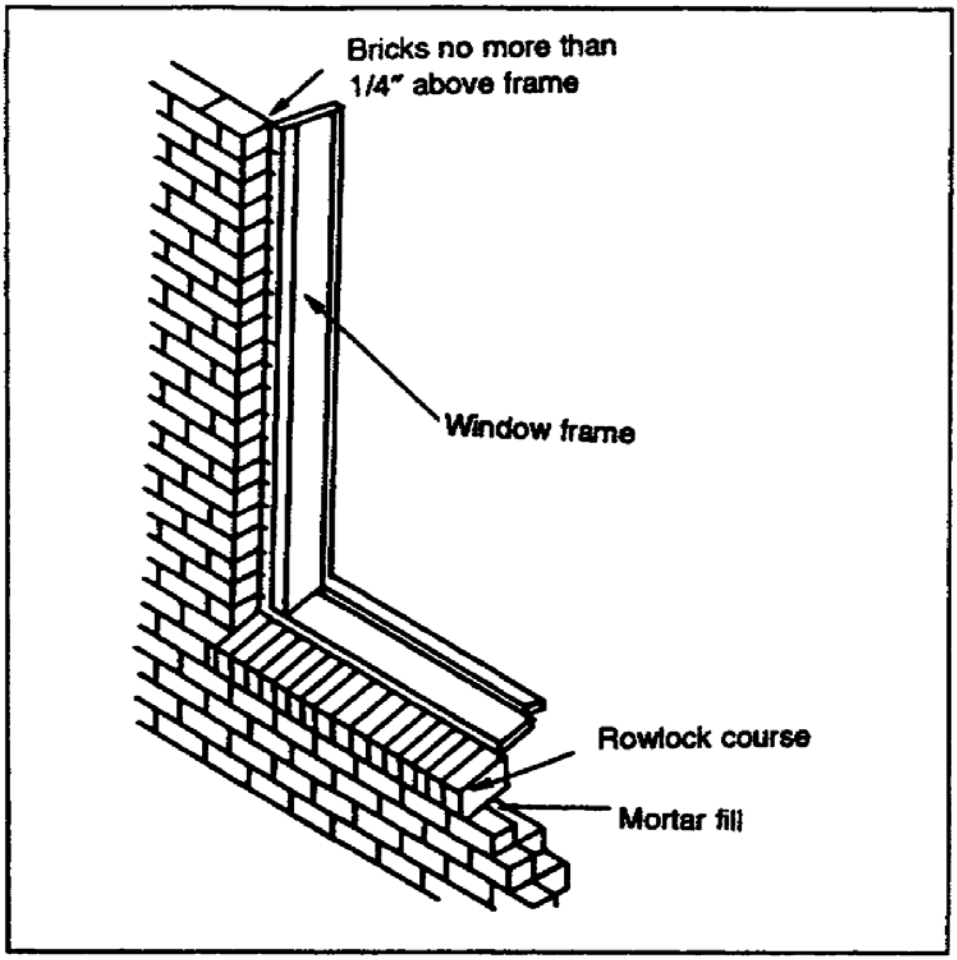

Figure 3-29. Bricks laid to the top of the frame

3-25. Finishing the Wall. Lay the upper courses of the corner leads according to the height of the courses for the window. After laying the leads, install the string line so that it stretches across the window opening (Part F, page 3-17). You can now lay the bricks in the rest of the wall.

3-26. Door Openings. The procedure for laying bricks around a door opening is similar to the one you used for a window opening. Cut pieces of wood the size of a half closure. Lay the pieces of wood in mortar as if they were bricks. Use either screws or nails to anchor the door frame to the wood. These wooden bricks are placed at several points along the top and sides of the door opening (Figure 3-30).

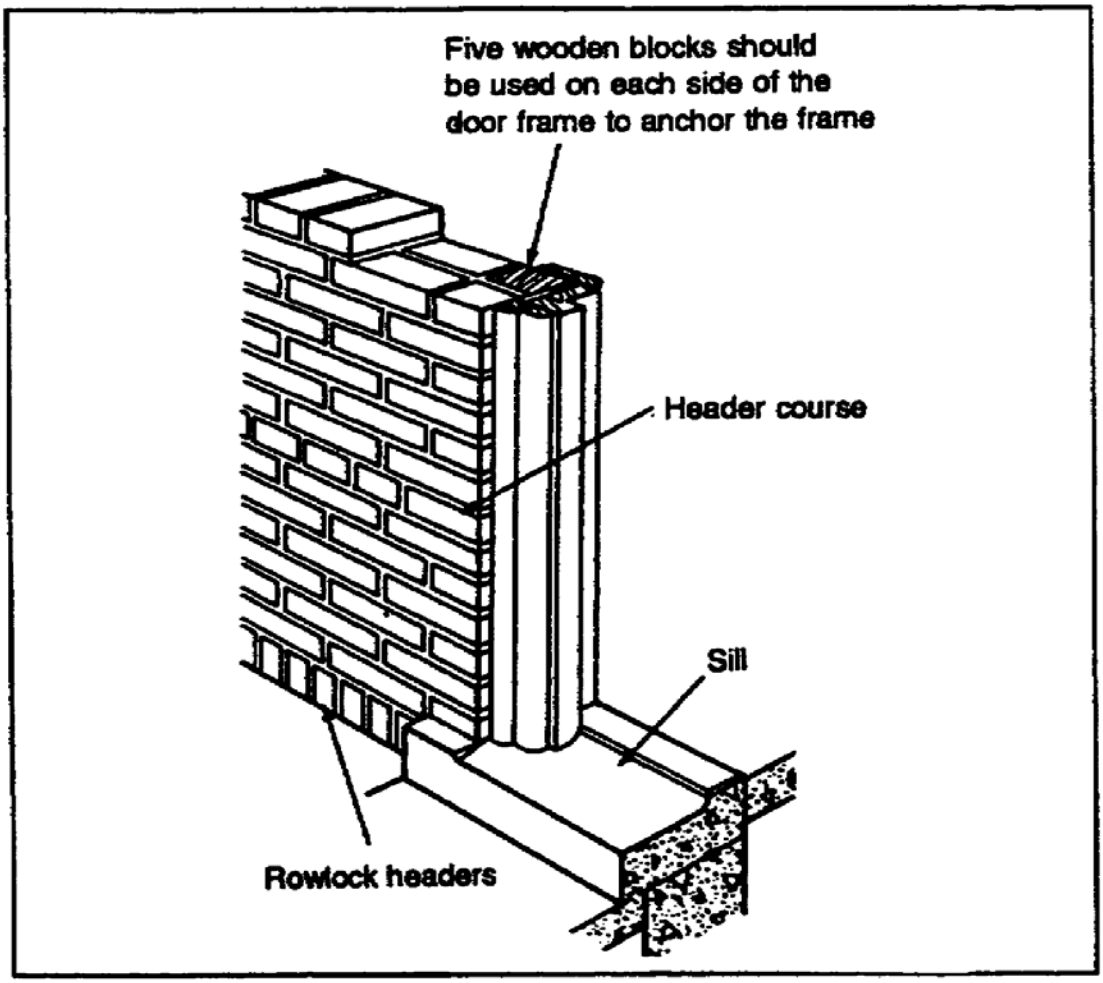

Figure 3-30. Constructing a door opening

PART H - LINTELS

Lintels are placed above the windows and doors to carry the weight of the wall above them. Lintels can be made of steel, precast reinforced concrete beams, or wood. Lintels rest on top of the last brick course that is level or approximately level with the top of the window or door frame (Figure 3-31). The bricks above the wall opening on which the lintels rest can be strengthened by the installation of steel reinforcing bars. The placement of the reinforcing bars is determined by the wall thickness and the type of window or door that is used (Figure 3-31).

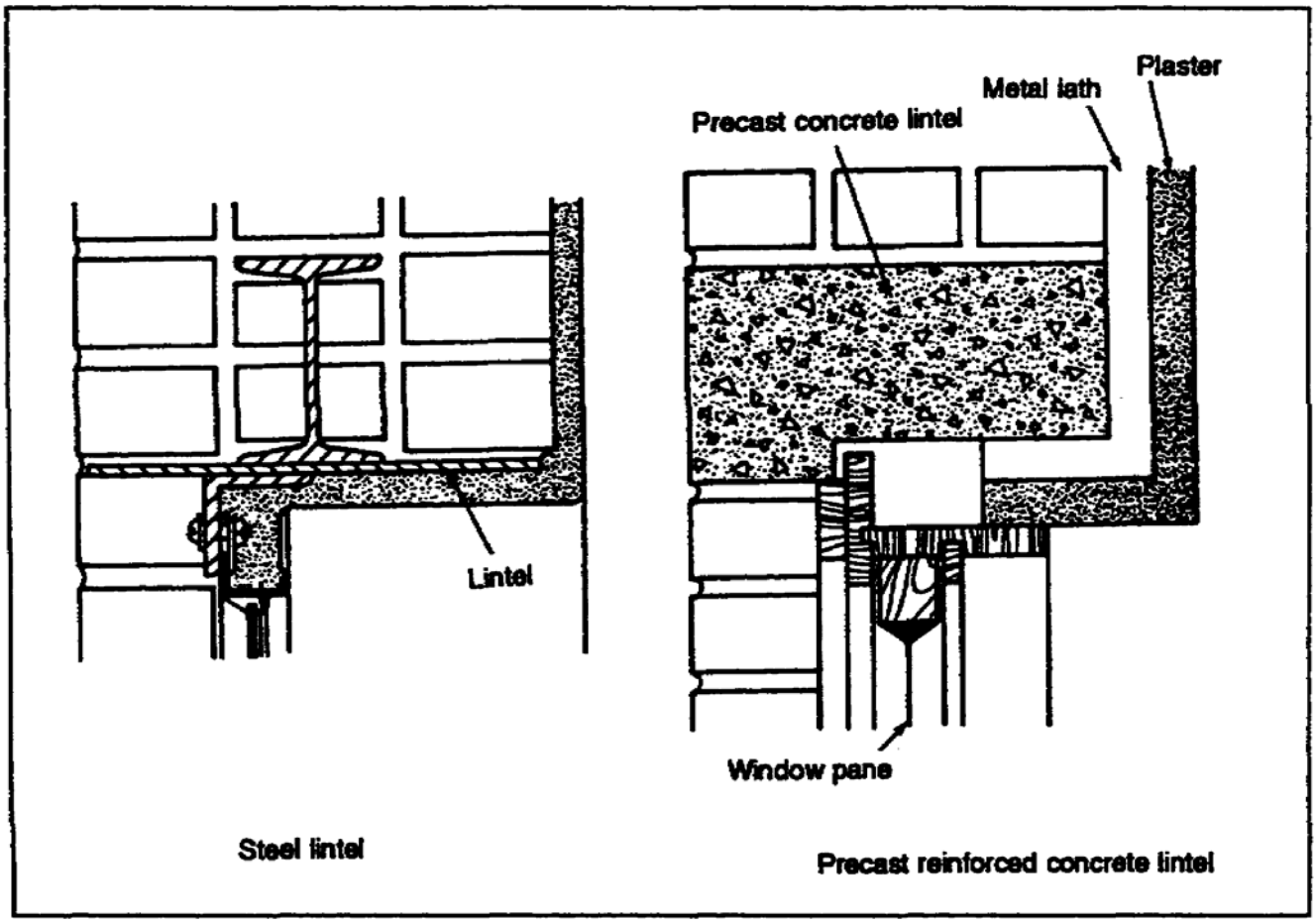

Figure 3-31. Lintels for a 12-inch wall

3-27. Lintel Sizes. Table 3-4 provides information about lintel sizes for various opening widths in 8- and 12-inch walls.

Table 3-4. Lintel sizes for 8- and 12- inch walls

Wall Thickness (inches)	Span				
	3-Foot		4-Foot * Steel Angles	5-Foot* Steel Angles	6-Foot* Steel Angles
	Steel Angles	Wood			
8	(2) 3 x 3 x 1/4	2 x 8 (2) 2 x 4	(2) 3 x 3 x 1/4	(2) 3 x 3 x 1/4	(2) 3 1/2 x 3 1/2 x 1/4
12	(3) 3 x 3 x 1/4	2 x 12 (2) 2 x 6	(3) 3 x 3 x 1/4	(3) 3 1/2 x 3 1/2 x1/4	(3) 3 1/2 x 3 1/2 x 1/4
Unless otherwise specified, all dimensions are stated in inches.					
				7-Foot* Steel Angles	8-Foot* Steel Angles
				(2) 3 1/2 x 3 1/2 x 1/4	(2) 3 1/2 x 3 1/2 x 1/4
				(3) 4 x 4 x 1/4	(3) 4 x 4 x 4 1/4
*Wood lintels should not be used for spans over 3 feet because they could burn out in a fire and allow the brick to fall.					

3-28. Double-Angle Steel. If you are using a double-angle steel lintel, it should be 1/4 in thick. This makes it possible for the two-angle legs to project up into the brick to fit exactly into the 1/2-inch joint between the face and backing-up ties (Figure 3-32).

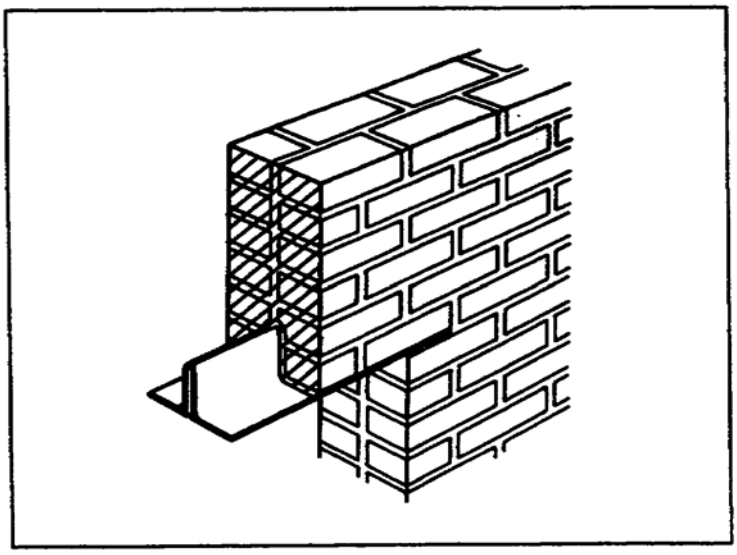

Figure 3-32. Double-angle steel lintels

Freezing and thawing breaks down the bond, which is the only type of weathering that affects brick. Therefore, the resistance of brick walls to weathering depends on their resistance to water penetration.

3-29. Tooling and Caulking. You can protect walls against moisture by making sure that joints are well-tooled and by caulking around door and window frames.

3-30. Flashing. The installation of flashing, strips of metal or roofing paper that is bent to fit mortar joints, is another method of protecting the brick against water penetration. Flashing keeps water from penetrating and directs it to the wall exterior. It is usually placed at the head and sill of window openings in some buildings and at the intersection of the wall and the roof (Figures 3-33 and 3-34).

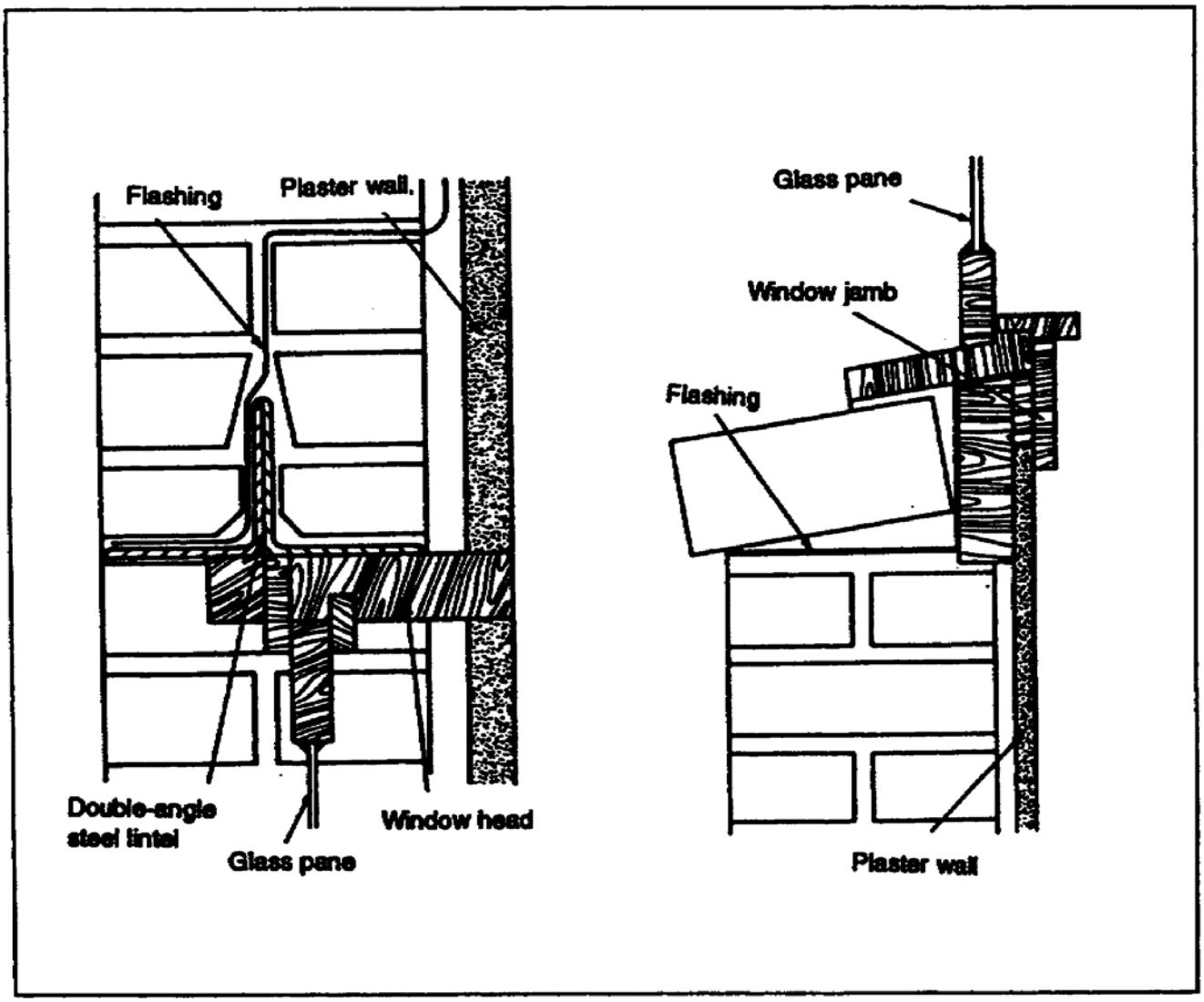

Figure 3-33. Flashing at the head and sill of window openings

3-31. Materials. The most common flashing materials are copper, lead, aluminum, and bituminous roofing paper (paper that has been coated with asphalt or a similar water-resistant substance).

3-32. Installation. Spread a 1/2-inch-thick bed of mortar on top of the brick and push the flashing firmly into the mortar. Place the brick or sill that goes over the flashing into a l/2-inch-thick bed of mortar spread on the flashing itself (Figure 3-33). Turn up the edges of the flashing to prevent drainage into the wall. Fit the upper end of the flashing into the groove of the raggle block and caulk it (Figure 3-34).

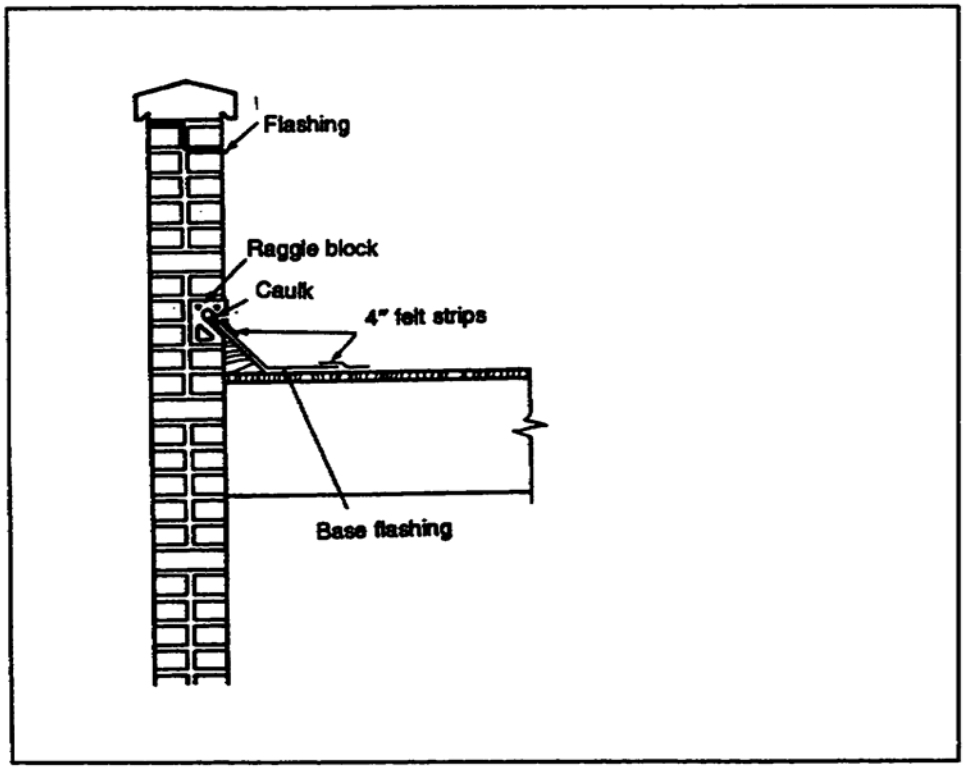

Figure 3-34. Flashing at the intersection of the wall and the roof

PART J - REINFORCED BRICK

When added strength is needed, brick walls, columns, beams, and foundations are reinforced in the same way as in concrete construction.

3-33. Spacing. The minimum spacing between steel reinforcing bars should be 1 1/2 times the diameter of the bar itself. When you lay reinforced bricks, the thickness of the mortar joint should be 1/8 inch more than the diameter of the steel bar itself. This allows for 1/16 inch of mortar between the surface of the brick and the reinforcing bar.

3-34. Bars. Reinforcing steel can be placed in both horizontal and vertical mortar joints.

a. Horizontal Bars. Lay horizontal bars in the bed of mortar, and then push them down into position. Spread the mortar on top of the bar, and smooth it until you have a bed joint of the proper thickness.

b. Vertical Bars. Place vertical bars in the vertical joints. Hold them in position by wood templates at the proper bar spacing, or wire them to the horizontal bars. Then lay brick up around the vertical bars.

c. Stirrups. Z-shaped steel reinforced bars, called stirrups, are shaped to fit the mortar joints. Place the lower leg of the stirrup under the horizontal bars. You may need to make the mortar joint thicker at this point (Figure 3-36, page 3-39).

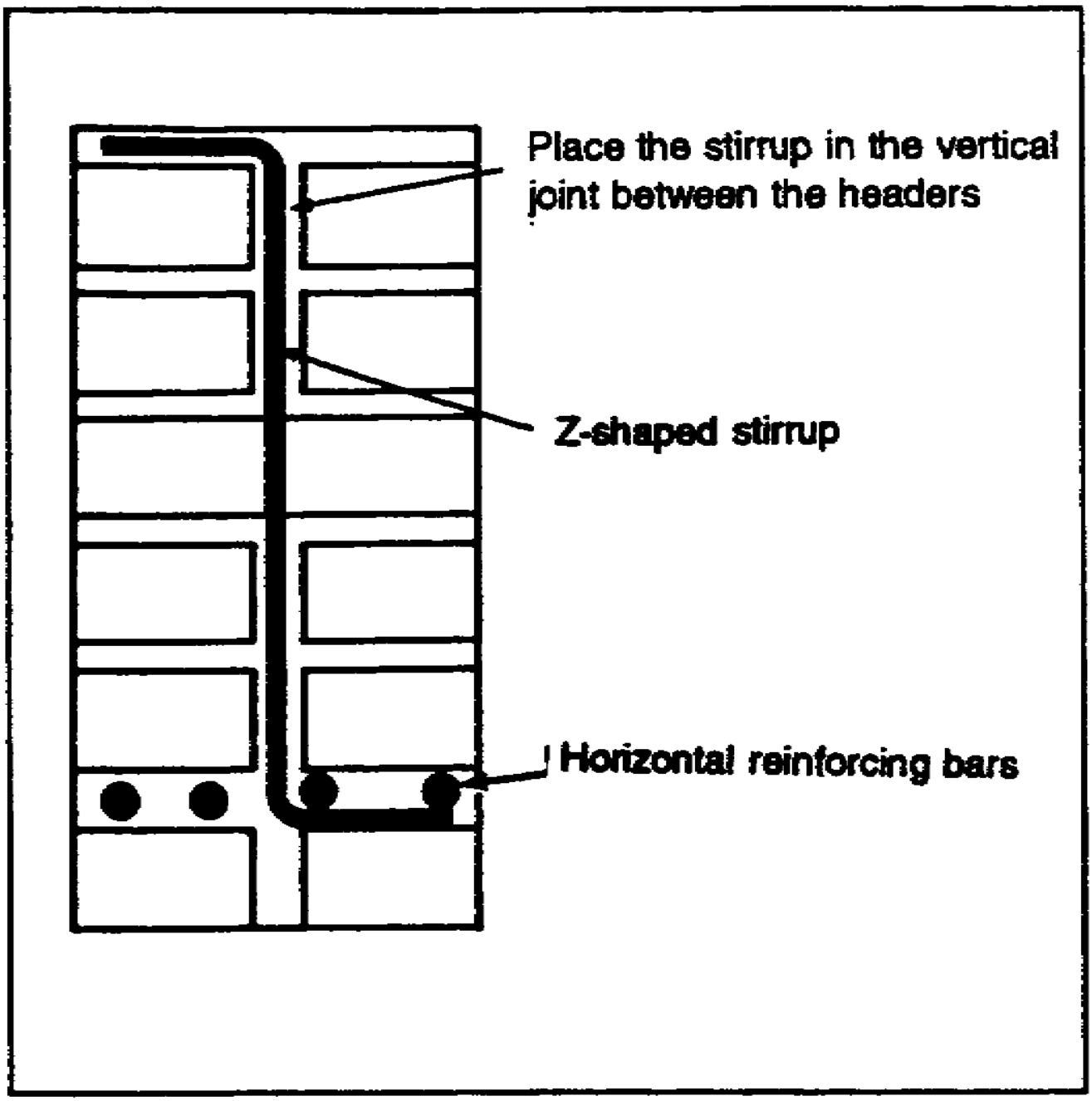

Figure 3-35. Reinforced brick-beam construction

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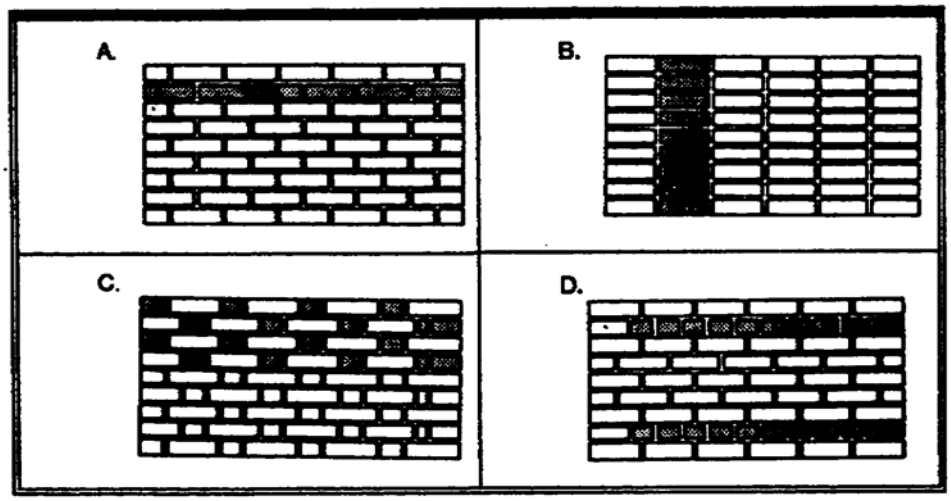
LESSON 3

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer to each item. When you complete the exercise, check your answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson that contains the portion involved.

1. Which of the following is a common bond?



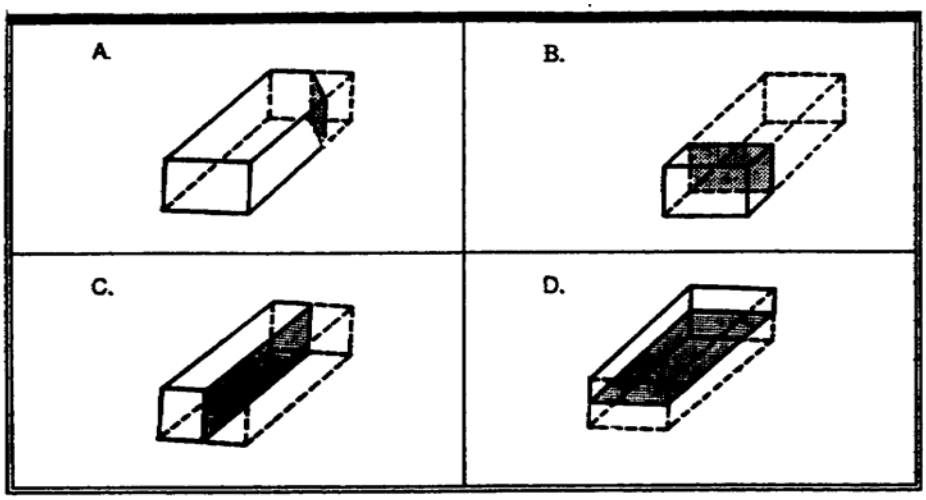
2. In what type of brick is the flashing set and caulked?

   A. Closure
   B. Header
   C. Stretcher
   D. Raggle

3. What type of brick is most commonly used in hospitals?

   A. Glazed
   B. Face
   C. Common
   D. Sand-lime

4. Which of the following is a king closure?



5. In brick construction, what are corner leads used for?

A. As a leader to other corners.
B. As support for bricks around window and door openings
C. As a connector for bearing to bearing walls
D. As guides for laying up the wall

6. When laying long walls, what should you use to keep the string line from sagging?

A. A nail
B. A trig
C. A small block of wood
D. A precast lintel

7. How many courses are there in a wall 9 feet 7 inches high, using 2 1/4-inch brick and a 5/8-inch joint? Refer to Table 3-3 on page 3-20.

A. 35
B. 37
C. 40
D. 41

8. What should be done with excess mortar after the brick is placed on a course?

   A. Let excess mortar harden and then tool it
   B. Cut off excess mortar and reuse it
   C. Cut off excess mortar and discard it
   D. Let excess mortar set and chip off with a hammer

9. Why are the edges of a flashing turned up?

   A. To hook into the bed of mortar
   B. To prevent drainage into the wall
   C. To act as a gutter and aid in runoff
   D. To make the sharp edges safer for workers to handle

10. Why are joints finished?

   A. To prevent waste of mortar
   B. To help hold brick in place
   C. To allow room for caulking
   D. To makes them weathertight

LESSON 3

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		Correct answer and feedback	
1.	D	Figure 3-2	(Page 3-5)
2	D	Raggle Fit the upper end of the flashing….	(Page 3-37, par 3-32)
3.	A	Glazed Glazed bricks are often used for walls….	(Page 3-3, para 3-3e)
4.	A	Figure 3-13	(Page 3-14)
5.	D	A guide The corner leads are used as guides….	(Page 3-21, para 3-14)
6.	B	A trig When a string line is stretched….	(Page 3-29, para 3-21d
7.	C	Table 3-3	(Page 3-20)
8.	B	Cut off and reuse The excess mortar should be….	(Page 3-12, para 3-9)
9.	B	To prevent drainage into the wall Turn up the edges of the flashing….	(Page 3-37, para 3-32)
10.	D	To make joints weathertight Joints must be finished….	(Page 3-13, part D, Intro)

APPENDIX A

LIST OF COMMON ACRONYMS

	foot (feet)
	inch(es)
ACCP	Army Correspondence Course Program
AIPD	Army Institute for Professional Development
ASTM	American Society for Testing and Material
CM	commercial
DA	Department of the Army
DOD	Department of Defense
DSN	defense switched network
EXAM	Examination
FM	field manual
ft	foot (feet)
in	inch(es)
IPD	Institute for Professional Development
MO	Missouri
MOS	Military Occupational Speciality
NO	number

RYE	Retirement year ending
SSN	social security number
STP	soldier training publication
TM	technical manual
TRADOC	United States Army Training and Doctrine Command
US	United States
VA	Virginia

APPENDIX B

RECOMMENDED READING LIST

The following publications provide additional information about the material in this subcourse. You do not need these materials to complete this subcourse.

FM 5-426. *Carpentry.* 3 October 1995.
FM 5-742. *Concrete and Masonry.* 14 March 1985.
STP 5-51B12-SM-TG. *Carpentry and Masonry Specialist Skill Levels 1/2 MOS 51B, Soldiers Manual and Trainers Guide.* 19 August 1987.

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